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# SCHOOL SCIENCE AND MATHEMATICS

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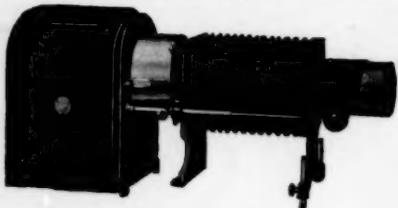
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# SCHOOL SCIENCE AND MATHEMATICS

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## THE CASE AGAINST HIGH SCHOOL MATHEMATICS.

BY MABEL SYKES.

*Bowen High School, Chicago.*

Recently criticism of the teaching of secondary mathematics has received rather wide-spread circulation. Our critics have even gone so far as to suggest that mathematics as ordinarily taught be entirely omitted from the high school curriculum. Much of this criticism appears to be based on the per cent of failures in the mathematics examinations of the College Entrance Examination Board, or in first-year high school algebra. We can understand why the outlook for secondary mathematics might be pretty dark if judgment is based entirely on some of the evidence presented.

Mr. Abraham Flexner in *A Modern School*<sup>1</sup> says:

It is perhaps worth while stopping long enough to show by figures the extent to which our current teaching fails. Complete statistics which would tell us how many of all the pupils who study Latin, and algebra, and geometry fail to master them do not exist. But we know that a large percentage of the better students of these subjects try the College Entrance Examinations, and that for these examinations many receive special drill in addition to the regular teaching. Now in the examinations held by the College Entrance Board in 1915, 76.6 per cent of the candidates failed to make even a mark of 60 per cent in Cicero; 75 per cent failed to make a mark of 60 per cent in the first six books of Vergil, every line of which they had presumably read and reread; 69.7 per cent of those examined in algebra from quadratics on failed to make as much as 60 per cent; 42.4 per cent failed to make 60 per cent in plane geometry. What would the record be if all who studied these subjects were thus examined by an impartial outside body? Probably some of those who fail do not do themselves justice; but as many—perhaps more—of the few who reach the really low mark of 60 per cent do so by means of devices that represent stultification rather than intelligence. For nothing is commoner in the teaching of ancient languages and formal mathematics than drilling in arbitrary signs by means of which pupils determine mechanically what they should do, without intelligent insight into what they are doing. It is therefore useless to inquire whether a knowledge of Latin and mathematics is valuable, because pupils do not get it; and it is equally beside the mark to ask whether the effort to obtain this knowledge is a valuable discipline, since failure is so widespread that the only habits acquired through failing to learn Latin or algebra are habits of slipshod work, of guessing, and of mechanical application of formulas, not themselves understood.

<sup>1</sup>Publications of the General Education Board. Occasional Papers, No. 3, p. 6.

The case, however, should not be considered as closed until some investigation is made of the evidence presented.

A mere glance at the examinations set by the College Entrance Examination Board and at the results of these examinations suggests two points worthy of consideration in this connection:

1. The number of successful candidates in all the examinations of the College Entrance Examination Board for the last eight years ranges from 48.8 per cent (1909) to 54.8 per cent (1913) of the total number of candidates who apply.

2. The definition of the algebra units given by the Board<sup>2</sup>, and the examinations based on this definition, set a standard for first-year algebra work that many high schools might not be willing to accept.

The accompanying table gives the percentages of all candidates that received a mark of 60 or above in the examinations of the Board for the dates and in the subjects given. The figures are from the Annual Reports of the Secretary of the Board. The reports of the Secretary give the results of several examinations under certain of the general heads. These were not copied. For example, there are four examinations in history, eight in Latin, and so on.

|                  | 1909. | 1910. | 1911. | 1912. | 1913. | 1914. | 1915. | 1916. | Average. |
|------------------|-------|-------|-------|-------|-------|-------|-------|-------|----------|
| All Exams.....   | 48.8  | 51.2  | 52.7  | 54.4  | 54.8  | 52.1  | 52.2  | 49.6  | 51.9     |
| English.....     | 56.6  | 48.8  | 50    | 53.7  | 48.3  | 51.6  | 43.1  | 41.8  | 49.2     |
| History.....     | 39.6  | 37.5  | 45.6  | 33.8  | 38.1  | 34.4  | 31.8  | 29.1  | 36.2     |
| Latin.....       | 38.2  | 52.8  | 61.6  | 55.9  | 51.4  | 56.4  | 59    | 63.1  | 54.8     |
| Greek.....       | 48.7  | 59.4  | 59.2  | 65.5  | 73.4  | 67.7  | 76    | 57.0  | 63.3     |
| French.....      | 63.5  | 55.3  | 56    | 63.7  | 60.5  | 61.9  | 61.5  | 73.7  | 62.0     |
| German.....      | 47.4  | 50.6  | 48.9  | 47.5  | 57.1  | 48    | 57.9  | 50.6  | 51.0     |
| Spanish.....     | 78.6  | 50.   | 58.8  | 59.1  | 76.2  | 45.8  | 40    | 22.8  | 53.9     |
| Physics.....     | 54.9  | 56.9  | 53.8  | 42.4  | 58.5  | 55.5  | 59.3  | 49.8  | 53.9     |
| Chemistry.....   | 65.6  | 60.8  | 61.8  | 57.4  | 54.4  | 62.3  | 52.5  | 42.3  | 57.1     |
| Biology.....     |       |       |       |       |       | 58.3  | 62.5  | 48.3  |          |
| Botany.....      | 50.   | 43.8  | 44.8  | 50.   | 41.7  | 59.1  | 64.7  | 70.8  | 53.1     |
| Zoology.....     | 88.9  | 100   | 50.   | 90.   | 63.   | 63.   | 80.   | 62.5  | 74.7     |
| Geography.....   | 80.   | 91.7  | 43.6  | 35.9  | 48.9  | 26.7  | 35.5  | 50.   | 51.5     |
| Mathematics..... | 54.8  | 50.5  | 43.8  | 60.   | 60.7  | 48.6  | 47.7  | 40.5  | 50.8     |
| Algebra A.....   | 57.9  | 60.3  | 46.5  | 65.3  | ..... | 44.1  | 43.6  | 38.2  | 50.8     |
| Algebra A1.....  | 35.3  | 43.8  | 40.6  | 48.4  | 73.3  | 53.8  | 44.6  | 51.5  | 48.9     |
| Algebra A2.....  | 53.2  | 52.3  | 35.8  | 58.9  | 47.9  | 42.   | 30.3  | 46.1  | 45.8     |
| Plane Geom.....  | 56.6  | 39.8  | 33.9  | 55.4  | 59.4  | 40.8  | 57.6  | 38.   | 47.7     |

In 1911 the requirements in Latin were changed. Two sets of examinations were given. The per cent of successful candidates on the old requirements were 55.6 per cent, on the new require-

<sup>2</sup>Document 82, December 1, 1916. College Entrantee Examination Board, p. 36.

ments 67.7 per cent. We have used the average of these two figures. There are in all nine examinations in mathematics, namely: A, Elementary Algebra, complete; A1, Algebra to quadratics; A2, Quadratics and beyond; B, Advanced Algebra; C, Plane Geometry; D, Solid Geometry; CD, Plane and Solid Geometry; E, Trigonometry; and F, Plane Trigonometry. Only four of these, A, A1, A2, and C, seemed to be needed in the present discussion. The right-hand column was obtained by averaging the figures given in the corresponding horizontal rows.

It is evident from a glance at this table that the Board does not expect or wish more than about 50 per cent of the candidates to pass. One cannot help wondering why all of the mathematics teaching in the country should be condemned from the results of examinations that are evidently intended to exclude young people from college instead of admitting young people to college.

Mr. Flexner's figures for the per cent of failures in certain Latin examinations do not agree with those in the report of the Secretary of the Board for the year given. While his mathematics figures appear to be correct it is interesting to notice that the per cent passing in Algebra A2 in 1915 is the lowest per cent for any elementary algebra examination for at least eight years.

We may arrange the various subjects according to the average per cent of successful candidates. (See right-hand column.)

|           |       |         |       |             |       |
|-----------|-------|---------|-------|-------------|-------|
| Zoology   | 74.7% | Latin   | 54.8% | German      | 51%   |
| Greek     | 63.3% | Spanish | 53.9% | Mathematics | 50.8% |
| French    | 62.2% | Physics | 53.9% | English     | 49.2% |
| Chemistry | 57.1% | Botany  | 53.1% | History     | 36.2% |
|           |       |         | 51.5% |             |       |

It is not altogether evident from this list why Latin and mathematics should have been selected on a statistical basis as the especial objects of Mr. Flexner's attentions, and how history escaped. However, as mathematics in general and algebra and geometry in particular are pretty well down the list, a glance at the questions set is in order; for when a large per cent of the candidates fail on any given examination, the explanation may lie either with the preparation of the candidates or with the questions set. Mr. Flexner assumes that the only question is with the preparation of the candidates.

The Board<sup>3</sup> defines the requirement in elementary algebra, exclusive of advanced or college algebra, as consisting of two units each unit covering the work of one school year. This is assuming

<sup>3</sup>Document 82 (1916), pp. 14 and 36.

that four units constitute a full year's work. The work covered by the first unit includes the following topics:

1. The four fundamental operations for rational algebraic expressions.
2. Factoring, determination of highest common factor and least common multiple by factoring.
3. Fractions, including complex fractions, and ratio and proportion.
4. Linear equations, both numerical and literal, containing one or more unknown quantities.
5. Problems depending on linear equations.
6. Radicals, including the extractions of square roots of polynomials and of numbers.
7. Exponents, including the fractional and negative.

The second unit includes the remaining topics usually considered in elementary algebra together with binomial theorem and progressions. The use of graphic methods is expected. This definition is in accordance with the recommendations made in September, 1903, by a committee of the American Mathematical Society.

It would be interesting to know how many high schools throughout the country give two full years to high school algebra. There are certainly a large number that give only a year and a half. It appears as if the algebra examinations were set on the assumption that pupils had given more time to the subject than they generally have. The other subjects covered by the examinations seem to be based on the usual time allotment—one year to each of the sciences listed, four years to the usual Latin requirement, and one year to each course in history listed. Here again one cannot help but wonder why all the algebra teaching in the country should be condemned because of the results of examinations based upon two years' work, when many, if not most, pupils have spent but one and one-half years on it.

It may be that Mr. Flexner and others are assuming that first-year algebra is everywhere supposed to cover the seven topics listed above, and is everywhere expressly designed to prepare for this examination. If this is the case, we do not so much wonder at the condemnation. It is safe to say, however, that a large per cent of the high schools in the country would not be willing to acknowledge that the American Mathematical Society is the proper body to decide what shall be taught in ninth-grade algebra, and are not following *its* outline for Algebra A1 as *their* outline for first-year work. The following exercises are taken from the examinations in Algebra A1, and are among those to which objection might be made as proper work for first-year pupils.

1. Factor:  $a^2 - 6a - 4b^2 - 12b$  (1908)
2. Simplify:  $xy^{\frac{1}{2}} \left( \frac{x^{-\frac{1}{2}}}{y^{-\frac{1}{2}}} \right)^2 \div (x^{\frac{1}{4}} y^{-\frac{1}{2}})^{-\frac{1}{2}}$  (1912)
3. Solve:  $(3x - 11)^{\frac{1}{2}} - 2 = \frac{1}{3} (27x - 243)^{\frac{1}{2}}$  (1913)
4. Simplify:  $1 - \left\{ \frac{c^3 + y^3}{(c-y)^2} \div \left[ \frac{c^4 + c^2y^2 + y^4}{c^3 - y^3} \cdot \frac{(c+y)^2}{c^2 - y^2} \right] \right\}$  (1914)
5. Simplify:  $\frac{\sqrt{5} - 2\sqrt{6} + \sqrt{5} + \sqrt{24}}{3 - \sqrt{5}}$  (1916)

For further illustrations of these exercises we refer our readers to the papers themselves<sup>4</sup>.

As to the geometry examinations the Board states<sup>5</sup> that the questions in plane and solid geometry will be limited to propositions contained in the syllabus prepared by the National Committee of Fifteen, appointed by the American Federation of Teachers of the Mathematical and Natural Sciences and the National Education Association. This syllabus probably forms the most satisfactory basis for the examination that could be agreed upon. Many theorems often given in textbooks and mentioned in the New England Syllabus are omitted<sup>6</sup>. At least seven of the committee were secondary school instructors. Whether or not the questions based on this syllabus are relatively any harder than the questions in other subjects it is not possible for the writer to determine. It does seem, however, as if many of the original exercises were harder than they should be if the results of the examinations are to be used, as Mr. Flexner uses them, as a basis for judging the efficiency of geometry teaching in general. These original exercises often assume a wider acquaintance with geometrical facts than is assumed in the syllabus, and throw undue emphasis upon the less important theorems of the syllabus. These exercises often require considerable inventive genius and marked facility in stating geometrical facts in algebraic language. The following are illustrations of what is meant:

1. Show that the area of a regular hexagon inscribed in a circle is the mean proportional between the areas of the inscribed and circumscribed equilateral triangle. (1911.)

If the pupil has had considerable work with the triangles mentioned in this exercise, and draws his figure with the sides of the circumscribed triangle tangent at the vertices of the inscribed triangle, it is a very simple matter to show that the inscribed

<sup>4</sup>College Entrance Examination Board. Examination Questions in Mathematics. Second Series, 1906-1910. Third Series, 1911-1915. Ginn & Company.

<sup>5</sup>Document 82 (1916), p. 37.

<sup>6</sup>Final Report of the National Committee of Fifteen on Geometry Syllabus, p. 33.

triangle covers one-half the surface of the inscribed hexagon, and one-fourth the surface of the circumscribed triangle. Otherwise the exercise is liable to give considerable trouble.

2. A B C D is a rhombus, with A, C as opposite vertices. O is a point within the rhombus, such that  $O B = O D$ . Prove that A, O, and C are on the same straight line, *and that*  $A O \cdot O C = \overline{A B}^2 - \overline{O B}^2$  (1916.) (The italics are ours.)

3. Three equal circles, each tangent to the other two, have an acre of ground between them. How many rods in the perimeter of this acre? (1915.)

It should be noted that of the 10,631 candidates examined by the Board in 1916, 8,358,<sup>7</sup> or 78.6 per cent, were from the Middle Atlantic States and New England. Whether or not it would be fair to use the figures of the Board as a basis for criticism of a few eastern secondary schools we do not know, but the writer is very firmly of the opinion that Mr. Flexner's premises are wrong, and that his wholesale condemnation of current mathematics teaching is, therefore, unfair. The results of the examinations of the College Entrance Examination Board do not form a proper basis for judgment. It is perfectly possible that high school young people may have had work in algebra and geometry that is valuable in itself and in its training when these same young people fail to pass the mathematics examinations of the College Entrance Examination Board.

Again, of the 10,631 candidates examined by the Board in 1916, 5,494,<sup>8</sup> or 51.6 per cent, were for Harvard, Princeton, and Yale, and 2,754, or 25.9 per cent for nine other well-known eastern institutions, making a total of 77.5 per cent for twelve eastern colleges and universities. In general, high schools are something more than college preparatory schools. Most of them would strongly resent the implication that they exist for the especial benefit of these particular institutions. The problems of the secondary schools must be solved by secondary school men. One of these problems is the content of first-year mathematics. It is certainly time for the secondary schools to insist upon a restatement of the algebra units, and to insist that secondary school men have a large share in framing this statement.

According to other critics, high school mathematics is condemned on its own showing. Their arguments are based, not on the results of outside examinations, but on the per cent of failures in high school classes.

<sup>7</sup>Sixteenth Annual Report of the Secretary, College Entrance Examination Board, p. 45.

<sup>8</sup>Ibid., pp. 47 and 48.

The survey of the Denver public schools gives the per cent of failures in each high school for all subjects taught for both semesters of the years 1914 and 1915. Except for one high school, the per cent of failures in algebra is higher than for any other first-year study. The four figures for first-year algebra in the Technical High School are 14 per cent, 44 per cent, 50 per cent, and 50 per cent. Although all of the figures for the Technical High School are high, it is possible that this does not fairly represent their work. Averaging the four figures for each of the other four high schools, we get an average per cent of failures in first-year algebra of 25.7 per cent; the figures range from 15 per cent to 36 per cent. Averaging in the figures from the Technical High School gives 28.5 per cent.

Commenting on these figures, Dr. C. H. Judd, who made the survey, says<sup>9</sup>:

These figures for mathematics raise very pointedly the question, should algebra be required of all freshmen? If an instructor has to fail from 16 per cent to 50 per cent of his class, who is to blame?

The time was when the people and the students looked on the high school as an institution which selected certain people for a higher education, and said to others that they could not be admitted to the higher intellectual life. It was thought to be a mark of high efficiency in the school to fail a large per cent of the students. The day has come when people question a course which cannot pass more than seventy or fifty per cent of the students. Algebra must make a better case for itself than now seems possible, if it is to be kept in the curriculum as a required subject in first year.

Leaving for a moment the question of per cent of failures, one wonders if Dr. Judd's phraseology is otherwise wisely chosen. The function of the high school is certainly to give to each pupil the best education that the circumstances will permit; but if all work was so planned that all pupils would pass, would there be any higher life of any kind? If we make our work so that all moral strife is eliminated, the nation will swiftly degenerate. A higher implies a lower. After all is said that can be said to influence the point of view of the teacher, the fact remains that all children are not alike, and all homes are not alike. Some children are badly brought up. The influence of the school at its best can never be the controlling factor in a child's life. The question of what to do for the best good of a certain per cent of the children who fail, is a question that cannot always be answered by the work given or the manner of its presentation. In many schools a choice of courses instead of studies is offered to entering freshmen. Some courses do not require mathematics. Mistakes are made in selecting courses for individuals as it

<sup>9</sup>Denver School Survey Committee Report, Part II, pp. 158 and 159.

is often impossible to decide for what a fourteen-year-old boy or girl is fitted. Such a decision must usually be deferred until after adolescence. Even if first-year mathematics were elective, many pupils would find their way into the class who would better have taken something else. The problem Dr. Judd suggests is one for which there can never be a complete solution.

It is perfectly possible that the present solution of the problem is not the best one, but if figures are to be an important factor in the discussion, as some of our critics seem to wish, it would be well if data could be collected from a wide area covering failures and accompanying conditions in all high school subjects. Much of this data is available if one knew how to obtain it. There are many problems bearing on the question of ninth grade algebra that are capable of such statistical study. A few of them are suggested below:

A. It has been suggested that, other things being equal, the number of failures might bear some relation to the size of classes, and the time at the disposal of the teacher in which cases of failures could be considered individually; for, after all, failure is largely an individual matter.

Some special instances are interesting. In 1912 a committee of the Chicago High School Teachers' Club collected data on failures in the Chicago high schools. Of the first-year algebra failures reported at that time 61.7 per cent were from classes of forty or more. In 1914 a committee of eleven was appointed by Mrs. Young on standardizing the work of high school teachers. The report of this committee states that in many cases the teachers with the largest number of class appointments have the largest classes and the fewest free periods. With many conscientious teachers the real problem is how to give adequate attention to the individual when the teacher has six or seven classes daily with from thirty to forty, often more, in a class. The question of failures may be partly an administrative question.

A bulletin of the Extension Division of the University of Indiana contains failure data<sup>10</sup>, collected from two groups of high schools. Group I consists of six cities ranging in population from 7,000 to 30,000. Group II consists of five smaller cities. In every subject the average per cent of failures is larger for the schools in Group I. The report accounts for this in two ways: (1) the close personal contact of patrons with

<sup>10</sup>Bulletin of the Extension Division, Indiana University, Vol. II, No. 6, Third Conference on Educational Measurements, p. 188 and p. 184.

schools in small communities; (2) the small size of classes and the close personal contact between pupils and teachers in small schools.

It would be well if data could be collected showing how far the relation between failures and size of classes is confirmed by experience elsewhere.

B. The effect of supervised study on the number of failures in first-year algebra is another topic capable of statistical study.

Supervised study has been tried in the Joliet, Ill., Township High School for a number of years. Two years ago, at least, the faculty of the Joliet High School were very enthusiastic as to the results. There is no reason to suspect any change of attitude on the subject at this time. We cannot quote figures, however, as a letter on this subject addressed to the school in June, 1917, received no reply, probably owing to pressure of work.

An interesting experiment is reported from Indiana<sup>11</sup>. Three classes in the Bloomington High School under the same teacher were treated in three different ways, one of which was supervised study. The results at the end of the semester in per cent passing, showed 92.3 per cent of the class that had supervised study against 75 per cent and 83.3 per cent from the other two classes.

It would be well if data could be collected showing the effect of supervised study in other places.

C. It may be that the content of the required course in high school mathematics is not wisely chosen. Does the substitution of correlated mathematics reduce the number of failures?

In collecting data on this subject considerable care must be exercised. It is hardly fair to compare the results in Lincoln, Neb., where mathematics is first given in the tenth grade after a course in General Science in the ninth grade, with the results in places where algebra is given in the first year. In the University High School, Chicago, correlated mathematics is given in the first year, and the per cent of failures is very low; but it must be remembered that the entire faculty of the University High School has given especial attention to the question of failures in all subjects for a number of years, and that the maximum work required of teachers is four classes of twenty-four pupils each.

D. Is the per cent of failures in first-year algebra really so much greater than in other first-year subjects?

<sup>11</sup>Ibid, p. 193.

The report of the Board of Education of Columbus, Ohio, for the year ending August, 1916, shows a per cent of failures in first-year Latin and German that is as high or higher than that in first-year algebra. The same thing was true in St. Louis in the second half year, 1914-15, according to data collected by W. J. S. Bryan, Assistant Superintendent of Instruction, and in the two groups of schools in Indiana referred to above.

It is possible that there is nothing the matter with first-year algebra except the general tendency to make all first-year work too technical, a tendency to consider the subject as an organized whole that must be completed within the year, apart from its relation to the young people concerned.

High school teachers are very glad to consider the problem in all of its phases, but they seriously object to the omission of some of the most vital factors in the discussion, and especially object to wholesale criticism based on insufficient data.

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#### A COURSE IN THE APPRECIATION OF MATHEMATICS.

By DAVID H. MOSKOWITZ,  
*Boys' High School, Brooklyn.*

The days when the classics and mathematics were regarded as two of the sturdiest pillars of a fundamental education have gone by. Slowly but steadily these ancient towers have crumbled under the ceaseless drip of the waters of carping criticism. The classics are replaced by "modern" languages; mathematics by vocational pursuits. Science is afforded an eminent position, and never once does the idea arise that mathematics is a science, in fact, the science of sciences, to which might be given the foremost place of honor among the courses of study in secondary schools.

The notion is prevalent in the minds of the public that mathematics is one of those most difficult and presumably unnecessary subjects imposed upon their children in high school which should be, and therefore is, forgotten as soon as the requirements have been satisfied. This notion may have arisen through a number of channels.

Some of these people look back upon their own experiences with high school mathematics with a reminiscence of the great variety of apparently useless operations and manipulations that had to be mastered for no other ostensible purpose than to pass a much dreaded examination. They were taught to perform certain mechanical contortions to arrive at a result that

was no more evident than the acts themselves. True, there was a feeling of accomplishment; occasionally they discussed money, games, interest, trains and articles of everyday life; but this was only incidental. And the feeling of accomplishment soon vanished in the face of a greater difficulty. Again, the instructors made some very vague hints about engineers and scientists who needed this or that bit of information. But never once was the spirit of mathematics, its methods, its ideals, its accomplishments, revealed to the inquiring mind.

Even so, the boys and girls who graduate from our public high schools today entertain similar notions about mathematical study. A great number of them have pursued their study with interest, and have mastered the details, the content, with efficiency in the means of reproduction in examination. In addition, many of them are quite capable of applying their knowledge to original work, and to carry on more advanced studies therein.

But the greatest number is only moderately successful in mathematical study and they cease to continue the subject even if they go to higher fields of education. This vast throng of mathematical amateurs needs to have demonstrated to it the soul of mathematics, needs to be awakened to the beauty and harmony of the subject, needs to be thrilled with its unity, its transcendent influence, its absorbing philosophy.

At the present time the syllabi of the various mathematics courses are so filled with subject-matter that very little opportunity is afforded for the teacher to arouse this more important interest in mathematics as a field of knowledge. To accomplish this result there should be added to the high school curriculum a course in the Appreciation of Mathematics, a course that is to be built directly upon the mathematical training already inculcated. This course would be in the nature of a resume of the isolated branches as parts of a unified whole.

The following plan is offered, not as a fixed outline, but as a scheme that may be adapted to individual needs:

#### Lecture Course.

(With supplementary reading assignments) to be held two periods per week for one term. Open to all boys who have passed intermediate algebra. May be taken parallel with trigonometry, solid geometry, or advanced algebra. Topics:

- (1) Foundations of mathematics, elementary concepts: Definitions, axioms, postulates, operation, etc.
- (2) The principle of permanence in algebra.
- (3) The principle of continuity in geometry.
- (4) The principle of duality in geometry.

- (5) Non-Euclidean geometries: Geometry of Riemann, Geometry of Lobachevsky and Bolyai.
- (6) Hyperdimensionality.
- (7) The three famous problems: Trisection of the Angle, Squaring the Circle, Duplication of the Cube.
- (8) Appreciation of the importance of mathematics in the progress of civilization; applications; utility; "pure" versus "applied" mathematics with interesting historical sidelights.
- (9) Philosophy of mathematics.

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### SOME EXPERIMENTS IN GEOMETRY EXAMINATIONS ETC.

By W. M. FISHBACK,

*High School, Sacramento, California.*

At the close of last year's work I tried a couple of experiments in my geometry examinations that have been helpful to me, and I trust that they may be suggestive to others. The first was with two of my sections that had done but a half year's work, while the second was with a class that had completed the course for the year.

The first sections had studied to page one hundred seventeen, Wentworth-Smith Geometry. I asked them to open their books and pick out seven propositions in Book One and three in Book Two that they liked best, and tell why they liked them. Several of the students afterwards told me that they thought that they were going to have a snap, but after working for two whole periods they changed their minds. The data that I collected was both instructive and helpful to me, and the test was a departure from the old form of examinations, into which the students entered most enthusiastically. In many cases the reasons were, "Because the proposition was easy to understand"; but in many others the reasons were utilitarian, such as, "Helped me in cutting out a dress," and, "Helped me in setting up my tent."

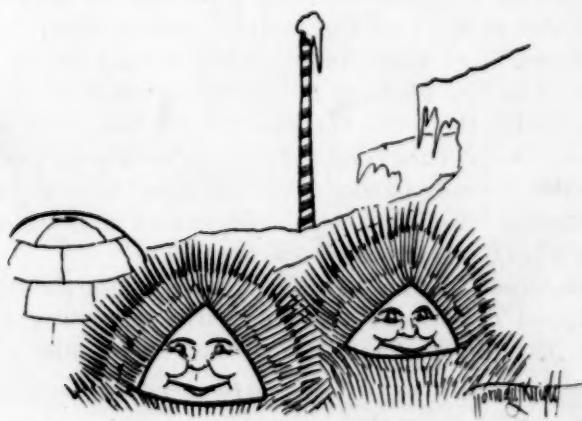
Out of forty who took this test, eighteen preferred as one of their ten, Proposition Nineteen; sixteen like Propositions One, Two, and Thirty-two, Book One; fourteen chose Eleven and Eighteen, Book One, and Eleven, Book Two; and no one selected the Twentieth. I have purposely given the extremes because I do not desire to weary the reader, but the data on the other propositions is interesting. I do not claim that these results prove anything, I simply state that they have been helpful to me here in this particular field, and something of the kind might be helpful to others.

The class that had completed the year's work had an entirely

different kind of a task. They wrote on "Geometry." If they liked it they told why they liked it, and if they "hated" it they told why. If it had been helpful to them they enumerated the instances and if any particular parts appealed to them they wrote those up. Of course the content of these papers was more interesting than that of the first sections, because this class had the advantage of having completed the subject and consequently could be more definite.

I shall give briefly some of the statements that were made. However, I should like to produce in full some of the papers that I received. "It teaches a person to reason and to talk logically." "Therefore, the study of geometry is a social requirement and an absolute necessity for the advancement of the human race." "It helps one to ask the reason for things." "Geometry teaches one to reason, and in reasoning rests the key to success and prosperity." "It has helped me to argue with my classmates, and not give in unless I have been proved wrong; and, greater than this, it has helped me to take a defeat cheerfully." A majority of the pupils stated that geometry had helped them to reason.

The experiments were worth while to me because I now feel more optimistic over my work in geometry. With this pile of evidence before me I feel that the subject is most valuable to the boys and girls who have been with me but one short year. I also feel that the experiments were worth while to the students because they told me so and because I know that they summed up for themselves what they had gained by their labor.



POLAR TRIANGLES

**RECENT DEVELOPMENTS IN ACOUSTICS OF BUILDINGS.<sup>1</sup>**

By F. R. WATSON,

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Our knowledge of the acoustics of buildings has been extended in recent years along certain lines; and while there is yet much to be learned, a fund of information has been accumulated from the results of experimental work and has been tested by practical application. The principles evolved from these investigations are thus available for attacking further problems where the acoustical phenomena are not well understood. The discussion in this paper is limited to three topics, the acoustics of auditoriums, the non-transmission of sound, and vibrations in buildings. It will be seen that these subjects are not independent, since the fundamental phenomena of acoustics are involved in each case.

*Acoustics of auditoriums.*—Twenty years ago little was known about the acoustical properties of auditoriums. A few practical suggestions were set forth for the avoidance of acoustical defects but the repeated failures to obtain satisfactory acoustics showed that these suggestions were of little value. On the theoretical side, Lord Rayleigh<sup>2</sup> showed that sound energy is dissipated into heat in narrow channels, or pores, thus explaining the absorption of sound by porous bodies. He was led by this investigation to suggest that reverberation in auditoriums could be minimized by the application of porous bodies, such as tapestries, curtains and carpets, to the walls and floor of the room.

The modern practical methods of correcting acoustical defects in auditoriums originated in some experimental work by Professor Sabine at Harvard University.<sup>3</sup> Sabine showed that the reverberation in an auditorium depends directly on the volume of the room and inversely on the absorbing power of all the surfaces exposed to the action of the sound. He also determined the absorbing powers of the common building materials, so that now it is possible not only to correct the acoustical defects of an existing auditorium but also to calculate before an auditorium is constructed what its acoustical properties will be.

The materials that are effective when used for the correction of acoustical defects are those primarily possessing porosity. Hairfelt, flax, carpets, heavy tapestries and similar materials

<sup>1</sup>An address given on April 13 at the Twenty-ninth Educational Conference of the Academies and High Schools in Relation with the University of Chicago.

<sup>2</sup>*Theory of Sound*, Vol. II, Section 251.

<sup>3</sup>*American Architect*, 1900.

are porous and have marked sound absorbing properties. Porous stone is also found effective as an absorbent. The author experienced an interesting confirmation of this fact in Switzerland, when visiting the dungeon of Byron's "Prisoner of Chillon." This dungeon was formed in natural stone and would be expected to give echoes and reverberations when a loud sound was given forth. These disturbances, however, were almost entirely absent. Investigation showed that the walls were of stone which had been rendered porous by the action of water and were therefore good absorbers of sound. This sound absorbing property of porous stone has led to the manufacture of porous masonry and artificial porous stone for the purpose of acoustical correction.

Instances of auditoriums with defective or with satisfactory acoustics could be cited to illustrate the principles of this phase of acoustics of buildings, but it is generally sufficient to state that defective acoustics will be found in a room of large volume having rigid, non-porous walls and few windows or other openings. The correction for such a case may be brought about in two ways: by reducing the volume and by increasing the sound absorbing materials in the room. The reduction of volume is usually not practicable since it alters too radically the architectural design of an auditorium. The remaining alternative is to introduce a calculated amount of curtains, hairfelt, porous stone, etc., to reduce the reverberation to an acceptable value.

*Non-transmission of sound.*—Another acoustical problem that is now receiving considerable attention is the means of minimizing the transmission of sound through the walls of buildings. Modern efficiency demands soundproof rooms. In hospitals, the patient should be protected from disturbing sounds; in hotels, the guests demand quiet rooms; in factories, the noise of machinery should be kept from the offices. The success of such soundproofing depends on the non-transmission of sound. The solution for the non-transmission, in turn, involves a consideration of the amounts of sound reflected and absorbed, since, on striking a wall, the incident sound is partly reflected, partly absorbed, and the rest transmitted. It must be apparent from this action that non-transmission of sound is brought about by using materials that will reflect and absorb sound.

The selection of suitable materials to give large reflection is prompted by the theory of the subject which indicates that reflection takes place at a boundary between two media when there

is a change in elasticity or density. Thus a rigid masonry wall is much more elastic and dense than air, so that sound waves in air will be strongly reflected from a masonry wall.

Experimental work on this general problem has been undertaken by the author.<sup>4</sup> Sound of a definite pitch from a steady source is directed against a specially prepared partition. The intensities of the transmitted and reflected sound are measured simultaneously by Rayleigh Resonators.<sup>5</sup> The results show that the amount of sound transmitted is diminished very greatly by increasing the thickness of the material, the intensity diminishing according to an exponential law with the thickness.<sup>6</sup> The intensity of the reflected sound appears to increase regularly with the thickness, at least for small thicknesses. Jager<sup>7</sup> has shown that the reflection depends on the density and rigidity of a non-porous wall.

The problem of non-transmission of sound in a building is a complicated one because of the complexity of the building structure. Precautions taken to build walls supposedly sound proof do not always prevent the transmission.<sup>8</sup> Sound will find its way along ventilating ducts, metal pipes, steel girders, and in various paths almost impossible to trace. The general principle to follow to minimize transmission is to combine building materials in such a way as to produce sudden discontinuities in density or elasticity so that sound is reflected. It is also desirable to insert materials to absorb sound.

*Vibrations in buildings.*—Another large acoustical problem in buildings arises because of the vibrations of walls, floors, and other portions, since it is found generally that these vibrations produce sound. A systematic investigation of this subject was carried out by Professor Hall<sup>9</sup> at the University of California. He used a modified seismograph pendulum that recorded vibrations in three directions, two horizontal vibrations at right angles to each other and a third vertical vibration. The results showed that buildings vibrate to a greater or less extent because of machinery, street traffic, and other causes.

The magnitude of the vibration is generally small, varying in Hall's observations from about .0001 to .03 mm.; but it is likely

<sup>4</sup>*Physical Review*, January, 1916, page 125.

<sup>5</sup>*Philosophical Magazine*, Vol. 14, page 186, 1882.

<sup>6</sup>See also article by Sabine, *The Brickbuilder*, Feb., 1915.

<sup>7</sup>"Zur Theorie des Nachhalls," *Sitzber. der Kaisl. Akad. der Wiss. in Wien. Math-natur. Klasse*, Bd. CXX, Abt. IIa, Mai, 1911.

<sup>8</sup>Sabine, "The Insulation of Sound," *The Brickbuilder*, Feb., 1915.

<sup>9</sup>"Graphical Analysis of Building Vibrations," *Elec. World*, Dec. 18, 1915. Also earlier papers.

that vibrations of factory floors exceed these values. The frequencies of the natural vibrations of the building structure vary from about six to nine per second, but those due to machines are usually higher. The vibrations produce sound waves and may be perceived as musical sounds if the frequency exceeds thirty vibrations per second.

Shaw<sup>10</sup> has shown experimentally that a telephone membrane vibrating with small double amplitudes varying from .00014 to 1.0 mm. gives sounds that vary from those "just audible" to those that are "just overpowering." Comparison shows that Hall's values lie within the limits found by Shaw, and that therefore the vibrating walls of buildings would give sounds of moderate intensity.

More recently, this problem has been extended by others<sup>11</sup> from the economic standpoint, since it appears that these vibrations, particularly in factories, affect the physical welfare and efficiency of employees. The results of these investigations lead to the following recommendations for reducing the vibrations: First, to minimize the vibration at the source by using properly balanced machines and by mounting them on separate foundations or on heavy rigid floors; and second, to reduce transmission of vibrations by breaking the continuity of the structure so as to produce changes in elasticity and density, thus following the principles already set forth in regard to non-transmission of sound. In this connection, Hall<sup>12</sup> points out that the comparatively feeble vibrations of a machine may become greatly amplified in a nearby building because of the changes in the continuity of the intervening structure.

A summary of the results set forth in this paper shows that certain acoustical problems have been attacked with some degree of success by using scientific principles rather than "cut and try" methods or methods based on elusive suppositions. It is therefore a matter of hope that the unsolved acoustical problems, of which there appear to be a large number, may also yield their solution by a similar application of known laws and thus further add to the comfort and efficiency of humanity.

<sup>10</sup>Proceedings of Royal Society, Vol. 76A, page 360, 1905.

<sup>11</sup>Mr. Maurice Deutsch, New York City, and The Aberthaw Co., Boston, Mass.

<sup>12</sup>Engineering News, August 1, 1912.

**PHYSICS IN THE HIGH SCHOOLS OF TOMORROW<sup>1</sup>**

BY G. W. STEWART,

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"Physics in the high schools of tomorrow." What a splendid chance for prophecy! But if a prophet is to be "not without honor" he must limit the expression of his vision to a horizon that is not far removed from present-day facts. To be understood and appreciated he must remain within the region of apparent possibilities and must suggest modifications of, rather than reformations in, present practice. The subject is one that affords abundant opportunity, but reluctantly I close my eyes to the inviting expanse of the field and limit the discussion to several distinct points which are either of immediate importance or of peculiar interest.

It is well that the first point should be the content of the high school course in physics. If we are to look into the future we must inquire of the present. Have we become too zealous in the direction of increasing the quantity of physics taught in one course? Are we sacrificing thoroughness for a more informationally extensive program? Are we keeping pace with a changing environment? Are we organized in a manner that will encourage the most rapid improvement in the content of our high school physics? These questions need not alarm, for surely our present courses are, in point of fact, the outcome of several decades of teaching effort. But these questions are serious and must be thoughtfully considered. Let us put them to a well-trained, thoughtful teacher of physics. He earnestly wishes to teach in a manner that will produce the results that he believes to be the most important. If he introduces in the course an additional carefully selected amount of material in the hope that the students will get a broader view of physics, he will discover that he has lessened their acquaintance with any part of it. If he reduces the number of principles taught and seeks through the aid of much experimental material to make these principles more concrete, he will learn that his students are omitting important portions of the subject and thus are not securing a *thorough* course in physics. If he gives great diligence to his teaching, earnestly striving to improve laboratory experiments, classroom problems and test questions, he is warned that physics is not confined to texts and laboratories but exists everywhere about him, indeed, throughout the universe, and that he should get his mind off from his books

<sup>1</sup>Read before the Physics Section of the C. A. of S. and M. T. at Chicago, Dec. 1, 1916.

and his laboratory environment. If he attempts to illuminate his teaching in mechanics by the study of toys, he is accused of teaching "toy physics." Thus our teacher is confused, for movement in any direction brings forth the suggestion of a counter movement. He will listen to all, but, in the end, he must adopt a program that is his own. Thus, gradually, by these individual decisions the content of high school physics is being modified. Although believing thoroughly in individualism, I must offer an objection to our confident reliance upon the individual effort just described. The reasons for the objection are two. The first is that, in view of our rapidly changing environment and the many important additions continually being made to physics, the problem of content is too serious to be solved by individual effort alone. The second reason is that, in truth, the subject of content has not reached that condition of stability which justifies satisfaction in the gradual improvement produced by individual effort. But some will contend that I am uninformed and that we have settled down to a satisfactory one year's course in physics which, although needing slight modifications from time to time, will remain practically constant in content. Very little argument is needed to show the fallacy of such a position. For instance, the introduction of physics in the first year as a part, and in certain texts as the greater part, of a general science course. This introduction has been made in response to an apparent need, a need that we as teachers of physics either have failed or have refused to recognize by a definite plan. Is not this single fact of the introduction of physics in the first year a convincing argument? We do not face the fact squarely if we say, "Well, that's general science and not physics," for the name of a course is not intended to distract. The course in general science is a course in elementary science, one in which physics is destined to play a conspicuous part. In the interests of the physics in the high school of the future I urge a vigorous, *organized* effort on the part of this section to study the question of the content of physics in the high school course. Such an organized effort can without error make two assumptions: First, that the limitation of science instruction to single isolated courses of one year each will gradually but inevitably disappear; and second, that science instruction in our high schools will increase.

A discussion of content leads at once to a consideration of our second point, namely, the *position* of physics in the four year high school course. I am fully aware that this Association has

a standing Committee on a Unified High School Science Course, but a brief consideration will persuade that we cannot depend upon this Committee for an adequately progressive program for physics. The committee, by the very nature of its organization, must act in a conservative manner, with equal justice to all sciences. While this form of cooperation of all the sciences is advisable, and indeed indispensable, I am convinced that the efforts of the committee should be assisted and encouraged by active committees in each section of the Association. And I speak especially with reference to physics. Let us see what was reported<sup>1</sup> by this excellent committee as to the position that physics should occupy in the high school course. Listen! In the first year, general science; in the second year, life sciences; and in the third and fourth years, "different radiating lines of science studies," such as "physical and chemical science, domestic science, agricultural science and elective sciences." Think of physics and chemistry being placed in a group of "radiating lines of science." Radiating from what? I should very much like to see the members of this standing committee face one incontrovertible fact and to make their decision compatible with it. That fact is that physics is distinctly the *basic science*. By that I do not mean that it is superior. But I do intend to say that the effort of the leaders of all sciences is to explain the phenomena studied in terms of physics and chemistry, and that the leaders in chemistry go one step further and attempt seriously to seek explanation of chemical phenomena in terms of physics. Can the committee deny these statements? Then how can its members justify the position of physics as a "radiating" instead of a basic science? The committee would probably answer that the report merely accepts the decision of the teachers of physics themselves, for have the latter not insisted upon teaching physics in the third and fourth years? Yes, it is true, and we must withdraw our complaint against the committee. We have been too anxious to have preliminary training in mathematics, and too zealous to teach a great quantity of physics and have allowed our anxiety and zeal to influence our judgment in much weightier matters. Verily we have swallowed the camel and strained out the gnat. For have we not placed physics in an inferior position? To this question I must answer "yes," for it would be scarcely fair to place such a basic subject in a position which in practice is somewhat inaccessible. Moreover,

<sup>1</sup> See report in *Proceedings* for 1913, p. 23.

an important committee has placed physics in a group of radiating sciences and this section has accepted such a classification without objection. Surely our modesty surpasses our judgment. We should look at the matter squarely and determine thoughtfully as to whether or not our decision as to the position of physics is in accord with the real mission of that subject in our educational program. I cannot assume to decide this matter today, but it seems clear that we could have a committee of this section to consider seriously the problem of the position of physics in the high school course. This is not an argument against co-operation with the other sciences through the standing committee of the Association, but it is a recognition of the fact that clear thinking upon the part of each participant must precede any successful and commendable effort at cooperation. But you ask, "How can you change the position of physics? What will you do?" And by these questions you may think you have stopped my somewhat theoretical plea. But I am not done. If physics is a basic science and should occupy a correspondingly important position in the high school course, then we must accept that decision as a fundamental one. In any constructive program, he who allows himself to become entangled in details and to take his mind from the fundamental object in view will invariably fail. Real leadership is not dismayed at details, but is persistently adherent to the fundamental object to be obtained. The fundamental object, my friends, is to place physics in its proper position as a basic science and to adjust the details of the program to that end. Our duty is clear. But some one is tempted to ask another question. Perhaps it is this, "Do you not forget that general science is now taught in the first year and that the physics taught therein occupies its proper position as a basic science?" The point in the question must be admitted. Physics is taught in the first year, and the continued success of a course in general science will depend very largely upon its inclusion of physics. But I am not willing, and you should not be willing, to permit the control of the teaching of physics as a basic science to pass into other hands. Physics teaching is our definite responsibility. Perhaps there is a grain of comfort in being left with a course in more advanced physics which we yet control. But an isolated, aristocratic position never satisfied a human soul that really desired to be of service. We must ever remember that we in a peculiar sense have in our keeping the mission of physics and that it is not narrowness but breadth to

recognize that we are charged to perform the function of giving physics its proper place in our educational program. But let there be no misunderstanding. I argue neither for nor against a course in general science as the science course of the first year. It is brought into our discussion only for the purpose of presenting convincing evidence of the actual situation in relatively few words. About ten years ago, certain physicists were advocating a preliminary course in "phenomenology." I protested, and insisted that, if physics were properly taught, an introductory course would not be needed. But my protest neither stopped the movement nor modified our high school course in physics. The equivalent of the course in "phenomenology" was introduced under the name of "general science." I now recognize in its success a message to every teacher of physics, a message that cannot be denied, a message that is sufficiently concrete to persuade. I now see that perhaps the proper method of breaking up blind contentment is not argument but the introduction of a new light which shall make the truth evident. If there is now a single member of this section who is satisfied with the functioning of physics instruction merely as a course in the third and fourth year, surely his blindness is permanent. Were I not addressing a section devoted to physics I should attempt to show that the problem in physics is somewhat similar to the problem in chemistry and to the problem in biology. I should contend that the signs of the times point unmistakably in the direction of an increase in science instruction in our educational program and should insist that these three sciences named are particularly in danger of missing the opportunities that are just ahead. But I am addressing the Physics Section and my remarks should perhaps be confined to a program for physics. While it would be helpful if we could discuss this question fully today, yet I, for one, would prefer to insist upon the appointment of an interested and aggressive committee, one that could meet in this city at least several times during the coming year. The duty of the committee would be to consider the question of the content and distribution of physics instruction in the high school, irrespective of the name under which that instruction is given. Surely, with the suggested organization of a general science section of this Association and the actual establishment of a general science journal, we believe there is great need for a constructive program for physics. Are we actually reverting to more elementary science and thus

apparently shelving our one year courses? The situation is clearly one that demands the closest scrutiny and study. Such a study is already being made by individuals. Last year before this section Professor Millikan proposed a change in our program which involved giving the physics earlier in the course and the simultaneous study of the three sciences, physics, chemistry and biology, for three years, each two hours per week. This proposal increases the amount of science instruction and throws physics earlier in the course. It also makes unnecessary the course in general science, excepting in those cases where the latter is obviously advantageous. I do not propose to discuss his suggestion excepting to remark that it is an effort to face our most important problem, the content and distribution of science instruction in the high school. But recently the Biology Committee of the National Educational Association has reported in favor of a two year course in elementary science. This committee is evidently convinced that our isolated single year courses in science have failed to meet the need in science instruction.

May I now turn from these interesting problems to two others that, though not of equal immediate importance, are peculiarly appropriate in this address. Their appropriateness is determined chiefly by the fact that they involve certain experiments made in the laboratory from which I come, and thus have a peculiar personal interest. The first problem might be termed that of "self-organization." An explanation is perhaps necessary. It is admitted that we differ as to methods of presentation of our subjects, both in the classroom and the laboratory. Discussions of these methods, such as are frequently had in this section, are of undoubted service. But, though each of us may receive suggestions kindly, yet his actual procedure is based upon his own judgment. The practical question thus arises as to how the teacher shall reach his judgment. In certain cases judgment can be easily rendered. For example, suppose we ask whether or not we should use the laboratory method of instruction. The answer is affirmative. This decision is not disputed, for we have much evidence in favor of laboratory work. But suppose the question arises as to the wisdom of using a certain laboratory experiment? Then judgment on the part of the instructor is not so easily obtained. We may well ask as to how this kind of a decision is almost invariably reached. Does not the instructor make an estimate based upon his past experience with students and upon his conception as to the

function of a laboratory experiment? Does he not arrive at his judgment without any attempt whatever at organizing his ideas? Let me illustrate by an actual case. Here is an experiment upon the moment of forces. The student finds it very pretty, for the sum of the moments on one side of the lever proves to agree very closely with the sum of the moments on the other side. Moreover, the student sees that he can actually determine the weight of a body by means of the principle of equal moments. Thus he leaves the laboratory happy over his result. Very naturally this pleases the instructor. The latter, noting the apparent joy of his student, is strongly influenced to decide that the experiment is a good one. But is this his best judgment? Should the apparent pleasure of the student be such an important factor in the judgment of an experiment? Or, stated in another way, is the instructor conscious of those factors which influence him strongly in passing judgment, and does he approve of the relative importance with which they stand in his mind? Let the instructor attempt to organize his judgment. Suppose that he decides that, while an experiment should give pleasure to the student, this result is of small importance compared with the development of a real appreciation of the student's physical environment. The instructor then examines this experiment on the moment of forces and notices for the first time that it does not happen to connect with environment at any point. Indeed, though the student carries in the framework of his own body a veritable laboratory of levers, yet he leaves his work entirely unconscious of that fact. If the truth be told, the average student returns his lever to the teacher and leaves it there, both physically and figuratively speaking. Through such thoughts the instructor recognizes how he has been led astray in his judgment and that merely because he made no attempt at its organization. Consider another factor in the selection of laboratory experiments, namely, the question as to whether or not the experiment demands thinking on the part of the student. No instructor can estimate this unless he has a very clear notion of thinking. Here is a student at his laboratory work. The instructor observes that the student stops in the course of the experiment and hesitates, evidently attempting to recall something studied in the classroom. Is the student thinking? Is that the definition of the word in the mind of the instructor? Or does the instructor use Dewey's description of thinking, involving five steps? This illustration should be sufficient to show

that we instructors are entirely too confident of the correctness of our estimates of the value of a laboratory experiment. The instructor of the high school physics of the future will be one who is fully persuaded of the necessity of ascertaining, first, the factors he will recognize in passing judgment, and, second, the relative importance of those factors. But, do you ask, is organization of judgment not more theoretical than practical? I can answer by citing an experience. For three successive summers the speaker has taught a course named "The Teaching of Physics," and each year attention was devoted principally to laboratory experiments. After studying the function of the laboratory and the factors which must be considered in arriving at a judgment of the value of an experiment, a tentative system of grading was adopted, in which each factor was given a certain number of points, which indicated perfection in that respect only. Thus during the past summer, the six following were considered the chief requisites of an experiment: Producing an inquiry and a means of answering it, 25; furnishing an opportunity for thinking, 25; cultivating an appreciation for environment, 18; furnishing an opportunity for the application of knowledge, 11; giving valuable knowledge of facts, 11; establishing transferable ideals, 10. At the beginning of this first study I had much confidence in the excellence of my judgment of an experiment. For had I not been teaching physics for 15 years and did I not have an appreciation of physics and of the function of a course in that subject? Yet, when I actually began to organize my judgment, I found glaring faults of importance in experiments I had previously thought excellent. Again and again I saw that the judgment attained through organized effort differed widely from my earlier estimates. The change in my judgments was so great that I was very conscious of the improvements. The added experience of the two following years has left me fully convinced that it is possible to organize the factors used in judging the value of laboratory experiments. Moreover, I am certain that such efforts will in time replace the loose manner now in vogue. The more capable the instructor and the broader his vision, the more valuable the organization of his judgment. Thus you see that I am implying that instructors in the future will be more capable and more thoroughly alive to their tasks. This must infer decided increases in pay and the raising of standards in the profession. The instructor in the high school physics of tomorrow will be one who believes in organiza-

tion, organization in groups for advancement, and organization of judgment in the individual. Permit me to leave no doubt upon one point. I am not setting up a standard method of judging laboratory experiments, but I am urging that each instructor set up his own standard method. The important thing is not that his standard be like mine, but that his standard be actually set up, that it be modified from time to time, and that it be utilized. But you protest by saying that many instructors in physics are not sufficiently familiar with their subject to organize a graded standard such as is here proposed. Upon this point I wish to make two comments. The first is that any sort of an organized standard set up by an instructor is distinctly superior to his own unorganized judgment. The second is an expression of hope that there may be published by this group a set of several standards, each one prepared by a recognized leader among us. These would be expressions of opinion in a form so concrete that any reader could sense the views of these men as to the function of laboratory physics. In concluding my remarks upon the need of organized judgment, I desire to remind you that the use of a grading system in arriving at opinions is not new, and that the only virtue of the present argument rests in this experimental evidence in favor of organized judgment with reference to laboratory experiments. But this idea is undoubtedly transferable to other problems connected with our teaching, and we can anticipate such a movement in the high school instruction of the future.

The last point selected for our consideration is that of the saving of time in physics teaching. The length of this address forbids an adequate presentation of this point and limits me to a brief reference to our experience with direct-reading, springless balances introduced by Dr. Sieg in the elementary physical laboratory. We are now using two such direct-reading balances having maximum loads of 500 and 1,500 grams. With each the mass can be measured to an accuracy of less than 1% over more than half the scale. This accuracy is sufficient in 90% of our present experiments, and we are persuaded that the apparatus in the remaining number should be modified to suit the direct-reading balance. Dr. Sieg assures me that it is possible to use these balances in all of our college laboratory experiments when modified. Surely the high school does not need greater accuracy than the college. The introduction of the direct-reading balance will be slow, but its use in the laboratory will be permanent.

The saving of time with such a balance is enormous. Indeed one can measure masses in 5 seconds of time, which is certainly twenty times as rapidly as a high school student can make the same determination on a beam balance. It is true that in certain experiments, our present equipment requires measurement to the hundredth of a gram, but why shouldn't such apparatus be built on a scale which would make the use of the direct-reading balance possible? The problem of the saving of time in our instruction, illustrated by the process of measuring mass, is a very important one indeed and well worthy the serious consideration of this group of laboratory teachers. Of course the securing of the direct-reading, springless balances was merely an application of common sense. But it is astonishing that such a device had not been previously used in the laboratory. Surely a serious effort to save time in our instruction has never been made.

In what I have thus far advanced, namely, an active interest in the content and distribution of instruction in physics, in the organized judgment of the teacher, in the saving of time in laboratory instruction, you have detected my belief that we are facing very serious problems, problems that demand of us who solve them, not only an extensive knowledge of physics, but also a vision of the future importance of science in education. What must our teacher of physics in the high school of the future know? Must he be an investigator? While I do not believe that he must actually engage in research, yet I am convinced that he must take an increased interest in research. Only he who learns to appreciate practically first hand the manner in which knowledge is acquired can hope to attain his highest success as a teacher of knowledge similarly acquired. Therefore the teacher must attempt to get into close touch with research. He must read such journals as the *Physical Review*. It is true that such reading may be very tedious, but unless our teacher is a real student of his subject he cannot hope to satisfy the demands of the future. But there is one requirement that is inferred in all the comments in this address. The successful teacher of the future must have creative ability and must exercise it. He must create. If he does not create in the sense of adding new knowledge to his subject, he must study and discover improvements in our interpretation and manner of instruction. As already stated, another demand of our teacher will be an appreciation of the future importance of science in the educational program. For just what is the attitude of the people of today toward science

and in what direction is it changing? In the realm of public health, the greatest scientific problem of the age, we find a rapidly increasing respect for the results of scientific research. People are much more obedient to the rules of quarantine, they are much more anxious to know the latest scientific opinion in matters of health, and they are much more alarmed concerning the presence of a disease not understood. Sanitary precautions and regulations are increasing in number everywhere. In the commercial world the achievements in telephony, in telegraphy, in illumination, in "doing everything electrically," has given the public a profound respect for research in science and a vision of what science will mean to the future. This is shown by the rapid increase of research laboratories in our manufacturing industries. The world is agape at the wonderful results produced by science within the last fifty years. Simply to enumerate the great achievements within those few years would be too ponderous a task for this address. But do the practical results which make this a distinctly scientific age give us a sufficient ground for the belief that instruction in science in our high schools will increase? Standing alone, they would not. But science has a much more important rôle in our intellectual life than the achieving of results in applications to commerce, to convenience and to comfort. All thoughtful people are interested in the effective use of intelligence. The knowledge obtained by science is knowledge that can be tested, and thus knowledge in its most certain form. Without a severe test we are very likely to err in our search and wander far from the path to truth. Every scientific investigator in the progress of a given piece of research indulges in many guesses, so to speak. Out of the many guesses only a few are found which are correct and which lead him to results. Only he who has actually tried such guessing can appreciate how readily the mind can develop a theory which is seriously an error and yet be wholly unaware of the possibility of error until experiment definitely shows that the error does exist. The test of theories by experiments selects the few that are soundest and truest and rejects the many that are false. A quotation from Professor John Dewey<sup>2</sup> will give the point of view of the philosopher, a deep student of methods of obtaining knowledge. In a recent paper, discussing science teaching, he writes as follows:

"Obviously science is not only knowledge, but it is knowledge

<sup>2</sup> General Science Quarterly, Vol. I, No. 1, p. 3.

at its best, knowledge in its tested and surest form. Educationally, then, what differentiates its value from that of other knowledge is precisely this superior quality. . . . "If we ask how this superior type of knowledge came into existence we find that men have been working their minds, more or less effectively, for many thousand years, and that for a very long time it was less rather than more effectively. But the most efficient ways of using or working intelligence have gradually been selected and cultivated. "And science as a personal power and resource is an equipment of all those found most successful, most effective. A man may have a good deal of cultivation, a good deal of information, correct information at that, about things, but if he has never made a first-hand acquaintance at some point with scientific ways of dealing with subject matter, he has no sure way of telling the difference between all-wool knowledge and shoddy goods. . . . Hence the rightful place of science in education is a fundamental one, and it is correspondingly important to see to it that methods of teaching are such as to fulfill its true purpose."

In conclusion, I trust I may be permitted to call attention to the suggestions for action made in this address. The content of the course, the position of the course, the suggestions of Professor Millikan and others as practical solutions of definite problems and our relation to the course in elementary science, now called "general science," are all matters that should receive the careful thought of a committee of this section. The other suggestions, namely, the possibility of setting up a half-dozen methods of organizing judgments with reference to laboratory reports, the possibility of extending the organization of judgment in other fields and the need of discovering and reporting methods of saving time in our instruction, especially in the laboratory, are of less importance, but are fully worthy of deliberation and action. If, in these busy days, we elect to make progress commensurate with our opportunities, organized effort is our only salvation. I am proposing nothing radical save in so far as aggressive study of our present situation may seem to be too progressive. Surely none can deny that we must get more light. Even now we are tardy, for are not these questions thrust upon us? Indeed they represent not problems met in anticipation, but problems that we have stumbled over upon our very doorstep.

## THE TEACHING OF BIOLOGY.

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The following is a select list of titles referring to the biological sciences, particularly as taught in the secondary schools and smaller colleges. The arrangement is chronological, beginning with the twentieth century. There are a few important references before 1900, but no effort was made to cover the literature prior to that year. The purpose of the bibliography is primarily to present the more modern points of view. So far as is known to the author, this is the only bibliography extant that brings the subject down to date, and that shows the sequence of material during the past seventeen years.

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**CHEMISTRY AS AN ELIMINATOR OF WASTE IN THE HIGH SCHOOL.<sup>1</sup>**

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The chief question in business administration or in school administration is how to secure the greatest efficiency. At the bottom of the desire for efficiency in business management we find only dollars and cents—efficiency is desired from a purely mercenary motive. In school management the impelling motive is somewhat different—it is the greatest educational good for the greatest number. Just as commercial firms today on every hand are striving for efficiency for the sake of material gain, so it behooves school administrators to interest themselves in efficiency for the sake of educational gain. The paramount question in the mind of every high school head today should be: How can my curriculum give the most to the general run of students in the shortest time?

There are many things which make for efficiency in the high school. One of the most important, if not the most important, of these is the elimination of waste. In every high school there are two kinds of waste as far as teaching is concerned: First, waste in the curriculum, and second, waste in the classroom. With waste in the classroom this paper does not concern itself. We wish to maintain the thesis that chemistry may be made the most efficient waste eliminator in the curriculum.

To begin with, let us take a look at some of the weak spots in the usual high school program, some of the things which could be eliminated or relegated to a less imposing position. The trend of the times is to adapt the material of the high school curriculum to varying social needs. Social needs vary from age to age, that is, historically, they vary in communities, and even among groups of individuals in the same community or institution. What was formerly considered essential in the high school is not necessarily so today. A subject important in the curriculum of one high school may be unimportant in another: for instance, city and rural students have different social needs. Again, in a given institution boys' needs are generally different from girls' needs, just as the needs of the different social classes vary. So in selecting subjects to be taught in a given institution it is not enough to show that they have some value, all subjects have that, but it must be shown that they have a value

<sup>1</sup>A paper presented before the Physical Science Section of The Association of Secondary Schools of the Upper Ohio Valley, at University of Pittsburgh, March 11, 1916.

not found in other courses which is of sufficient importance to justify giving the subject; and it must be shown that they have sufficient social value to justify the time spent upon them and that they are of more social value than other possible courses.

The first attack is upon geometry, next to Latin and Greek, probably, the most venerable study in the high school. Emerson once told mankind that "Education is what remains to us after everything we have learned at school is forgotten." Ninety-five per cent of the geometry learned in the high school is forgotten within a very short time. Why? Because it is generally of no use in practical, everyday life. Here then we have a subject whose social value is small, although the time spent upon it is generally large. True, geometry has its value—training in reflective thinking—but this end can be just as well served by other courses. It may also be essential to higher mathematics, but is it efficiency to cause the many to study geometry for the sake of the few who will need it for higher mathematics? Witness some figures from the New Castle High School:

Number in sophomore class, 180; number taking geometry, 148—boys, 88, girls, 60; number taking trigonometry who actually need geometry, 24.

These figures show that in this, a typical high school, about five-sixths of all second year pupils are studying geometry, and that it is a waste of time for eighty-five per cent of these. Similar conditions prevail in other schools. The training in thinking acquired in geometry is generally found to be of no use in other subjects requiring thought. Geometry is not fulfilling a useful purpose commensurate with the time spent upon it. Here, then, we have put our finger on a definite source of waste.

Let us now turn our attention to ancient and modern languages. First, what is the function of Latin and Greek in the curriculum? Obviously, the principal function is to help establish Spencer's principle that the ornamental comes before the useful. It is the prevailing fashion among parents to give their children a classical education. True, the time spent in four years of study of Latin in the high school is not wasted if a student can get in college certain necessary work which he might have gained in the high school. In such a case his more valuable college time is wasted. At any rate, all high school students do not go to college. In nine cases out of ten the high school student throughout his after career will find his Latin and Greek of

no practical use to him, so that it soon drops out of his memory. The charge of uselessness against Latin and Greek need not be prosecuted many years longer. The jury of school administrators is almost persuaded. It is only a matter of a short time until this source of waste in the high school will be eliminated by the introduction of something vastly more practical.

Somewhat similar are conditions in the case of modern languages. Why are they studied? The percentage of those studying them who will ever have occasion to speak them is small. There are only a few who ever utilize the books written in them. The real reason is that a knowledge of one or two of the modern tongues is thought to be a part of culture. Let us admit this virtue, for it is a real virtue, in modern languages. Another purpose of modern language instruction is to furnish a type of learning known as association of symbols and meanings. This is about the only one of the five types of learning which modern language study furnishes, a type which may just as well be furnished by a subject of practical social value. The emphasis placed upon modern languages in secondary schools is large, the results are not commensurate with the expenditure of energy, hence, this is a source of waste.

We have now seen that there are various sources of waste in the average high school. That geometry, Latin, modern languages, etc., serve some useful purposes, everyone will admit. We cannot eliminate them from the curriculum unless we provide something to replace the social value they have. If we can gain the social value of Latin and geometry and certain other studies as a side issue in a course having a high social value, then we have taken a great step toward efficiency and the elimination of waste. The remainder of this paper will be a brief statement of what may be accomplished in a suitably conducted course in chemistry.

Educators agree that there are five main types of learning: (1) Acquiring motor skill. (2) Associating symbols and meanings. (3) Acquiring skill in reflective thinking. (4) Acquiring habits of enjoyment. (5) Acquiring skill in expression. We shall endeavor to show wherein chemistry most efficiently subserves these five great aims of education.

First, acquiring motor skill. There are usually in the modern high school courses whose principal purpose is to promote this one aim of education. The most important of these, of course, is manual training. We do not mean to supplant manual

training by chemistry, but with regard to this one aim of education we can say that if the student be unable to elect manual training he will acquire more of the social value of the same through a course in chemistry than through any other course. Laboratory manipulation plays a large part in the average course in chemistry; thus the hand is constantly trained to act for the mind. Motor skill is acquired in a suitably conducted course in chemistry.

Second, associating symbols and meanings. It has been stated that this type of learning is furnished most by modern languages. But chemistry is a very rich field for associating symbols and meanings. Witness the multiplicity of symbols and formulae. It is quite an accomplishment, for instance, for the student to master all the meanings associated with a simple symbol such as O<sub>2</sub>, or a compound symbol such as CuSO<sub>4</sub>. 5H<sub>2</sub>O. Indeed, chemistry furnishes as much if not more practice in associating symbols and meanings than does any other subject. Every equation made up of symbols and formulae is a mine of meanings to the careful student of chemistry. The names of noted scientists, the various chemical terms, and they are various, are symbols with which the careful chemistry student associates meanings. If the training of the mind to bring about association of symbols and meanings is valuable, then the study of chemistry is as valuable in this one respect alone as is the study of a modern language.

Third, acquiring skill in reflective thinking. Here we have by far the most valuable purpose served by chemistry. Thus, by successively presenting such apparently diverse subjects as the difference between solid, liquid, and gas, the expansibility of gases, the diffusion of solids, liquids, and gases, Boyle's Law, Charles' Law, Henry's Law, etc., we can lead up to the kinetic molecular theory which, when properly presented to the student, becomes a profitable starting point of reflective thinking. The student then is in a position to *think* about the behavior of gases, about evaporation, about ignition, about temperature, about solution, about concentration effects, etc. With proper guidance from the teacher this one theory of chemistry becomes a potent factor in acquiring skill in reflective thinking, not to mention the potency of the ionic hypothesis and atomic theory in this regard. All the chemical generalizations, theories, and hypotheses, the derivation of formulae from percentage composition, the derivation of formulae and atomic weights by experi-

ment, are things very rich in material for reflective thinking. It is my practice to devote six or eight weeks in the chemistry course to work in qualitative analysis. The average high school student can do this work with great value to himself. Though it is largely a matter of following directions, the student is thrown on his own resources, his own initiative, and his own judgment; hence he is forced to think in order to do himself credit, and every student usually desires to do himself credit in this work.

With regard to the fourth type of learning, acquiring habits of enjoyment, chemistry does not, at first glance, so much concern itself. Training for the enjoyment of leisure time is one of the ultimate ends of education. Herein lies another function of chemistry. All sciences are interesting, chemistry in particular, and the poorest chemistry teacher can hardly fail to make his chemistry course interesting. Chemistry can furnish to most students the means of enjoying nature in all her various forms and phenomena. On account of the abundance of natural forms and phenomena, chemistry furthers this fourth aim of education to a very marked extent.

To inculcate the fifth type of learning, skill in expression, into my chemistry course, I have resorted to the following scheme, which is probably in use in many other places:

Subjects in the text, such as the fixation of atmospheric nitrogen, colloids, catalysis, explosives, potash, radium, fermentation, dyestuff industry, alloy steels, etc., are given only cursory attention, and are later made the subjects of special papers which will cover the field more adequately. A list of subjects for special papers is presented to the students and each one is asked to make five choices of subjects. The subjects are then assigned by lot about the last of February. The six weeks beginning March 1 are devoted to qualitative analysis, so that the student has plenty of time outside of school to spend on his research. At the end of the first week the student submits a list of references which he has found, and this list is then supplemented by the instructor. Next, the student submits a general outline of his paper before beginning work thereon. He then proceeds to acquaint himself thoroughly with the subject and write the paper. After April 15 the papers are taken up in the best logical order, the student appears before both chemistry classes (there are two classes), assumes the position of instructor, presents his subject, and evokes discussion for eighty minutes.

Theoretically, in this scheme the student should spend days and weeks in planning how best to express himself when his time comes. Whether or not he ever gets a chance, his work has an unconscious influence for good on him. Interest is stimulated somewhat by announcement that, if possible, good papers will be published in the local newspapers.

We have seen that chemistry may be made to embody the five great types of learning. At the present day it has not the popularity of geometry, nor modern languages, yet in actual social value chemistry takes wide precedence over these lines of study. In regard to relative worth, chemistry easily stands at the top of the list, with the possible exception of English. The social value of chemistry will last for ages because it is so practical. To quote Spencer: "The bleacher, the dyer, the calico printer, are severally occupied in processes that are well done or ill done according as they do or do not conform to chemical laws. The economical reduction from their ores of copper, tin, lead, zinc, silver, iron, are in great measure questions of chemistry. Sugar refining, gas making, soap boiling, gunpowder manufacture, are operations all partly chemical, as are also those by which are produced glass and porcelain. Whether the distiller's work stops at the alcoholic fermentation or passes into the acetous, is a chemical question on which hangs his profit or loss; and the brewer, if his business is sufficiently large, finds it pays to keep a chemist on his premises. Glance through a work on technology. It becomes apparent that there is now scarcely any process in the arts or manufactures over some part of which chemistry does not preside. Then, lastly, we come to the fact that in these times agriculture, to be profitably carried on, must have like guidance. The analysis of manures and soils, their adaptation to each other; the use of gypsum and other substances for fixing ammonia; the utilization of coprolites; the production of artificial manures—all these are boons of chemistry with which it behooves the farmer to acquaint himself. Be it in the lucifer match, or in disinfected sewage, or in photographs, in bread made without fermentation, or perfumes extracted from refuse, we may perceive that chemistry affects all our industries; and that, by consequence, knowledge of it concerns everyone who is directly or indirectly connected with our industries."

**THE SCOPE AND METHOD OF HIGH SCHOOL  
GEOGRAPHY.<sup>1</sup>**

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A definition of geography is always in order and I shall give you two. The first is an inadvertence by a boy who said that the earth is a ball, filled on the inside with dirt and worms and covered all over on the outside with nothing but geography. The second is the mature conclusion of a professor of geography in the University of London and a member of Parliament, who has said that "geography is not a science, but a state of mind." I will leave it to you to choose somewhere between these extremes. Some of us have been striving half a lifetime to define geography in the sense of setting limits visible from a central standpoint. The tendency now seems to be to sweep away limits and to regard all subjects of knowledge as having a geographical phase. Just as most things have a historical phase, a mathematical phase, an esthetic phase and many others, so whatever occupies terrestrial space and has a local habitation and a name is subject to geographical influences and laws. It is becoming evident that the geographer must claim the whole earth with fences removed.

In view of these facts the situation of the geography teacher is rather bewildering. In place of the old standard divisions, physical, commercial, political, he is faced by a number of strange, and more or less vague forms, which are knocking at the classroom door. Among these the labels economic, commercial, industrial, vocational, agricultural, biological, racial, and social, are prominent.

Among the topics we are asked to teach under the cloak of geography are the following: money, credit, banks, telephones, telegraph, typewriter, parcel post, bridges, tunnels, languages, printing, photography, music, hay loaders, corn huskers, cotton pickers, milking machines, incubators, spraying fruit trees, Bessemer and open-hearth processes, steam turbines, gas engines, oil engines, radioactivity, labor supply, labor unions, child labor, insurance, pensions, strikes, boycotts, injunctions, drainage, irrigation, dry farming, plant and animal breeding, the germ theory, flies, mosquitoes, sewage, garbage, antitoxins, aseptic surgery, anaesthetics, narcotics, intoxicants, tariffs, patents, immigration, railroad regulation, liquor traffic, war, disarmament. This list is a selection at random from geographi-

<sup>1</sup>Read before the Earth Science Section of the C. A. S. & M. T. at Chicago Dec. 1, 1916.

cal textbooks in actual use. Every one of these topics is worth studying and has some geographical relation, but it is asking too much of geography to become a melting pot for them and many more. By such diffuseness the very name of geography is brought into disrepute, and its place in the school curriculum into jeopardy. It is a time for all who believe in geography as a science and a worthy discipline to make special effort to save it from submergence in a pedagogic flood and to guide it in a safe and sane course. The only way seems to be to find some fundamental principles and to stick to them.

Geography originally had and primarily has to do with earth lore, or knowledge of our planet, as distinguished from knowledge of the heavenly bodies. In primitive times all science could be divided between geography and astronomy. The science of geology, born a little more than a century ago, has grown with vigor, and geographers have turned over to it the physical history of the earth and its inhabitants. It is ultimately a study of sequences in time and is organized by eons, eras, periods and epochs. Geography retains for herself the study of coexistences in space. The geologists are using all their resources in efforts to reproduce the geographies of the past and to establish the science of paleogeography. The geographer also deals with the earth and its inhabitants, but finds his hands full with the present earth and its living inhabitants. Since the inhabitants inside a few feet below the crust surface are dead, the interior of the earth is turned over to the geologist who has more use for it. The domain of the geographer lies chiefly in that part of the earth where land, water and air meet and commingle, the thin spherical shell inhabited by living creatures. His business is to discover the actions and reactions upon one another of land, water, air, plants, animals and men. Botany and zoology are equipped to handle the geographical relations of plants and animals, and are doing so vigorously under the name of plant and animal ecology. Who is there to look after the equally intimate and vastly more complex relations of human geography? Logically this task should fall to a human ecologist, but who is he? His name indicates that he might be a brother to the economist, but, if so, he is barely on speaking terms with the somewhat arid producer, distributor and consumer of wealth. Has not this human ecologist been going about his business modestly under the name of geographer? He has been accused of magnifying his office, but nobody has yet abolished it or taken his job away from him.

There are at least two fields in which the geographer holds undisputed sway; first, the field of explorer, surveyor and map maker, by whom the facts of distribution in terrestrial space are discovered and recorded; second, the field of man's relations to his natural environment. All knowledge belongs to the geographer, if he can make use of it, but other departments of science, outside these two, are held in common with other tenants. There are eminent members of Imperial, Royal and National Geographic Societies who believe that the making of a perfect map is the final cause and ideal end of geographic effort. Others equally eminent hold that the best possible map is only the beginning of real geography, the marshaling of the data upon which scientific geography is based. All agree that the ability to use maps, to read them and to think in them is an object of importance in geographical instruction. Teachers of pedagogy used to insist that the map idea is a horrible example of what is to be avoided, that to think of Indiana or Illinois as a red, green or yellow spot of a certain size and shape in the midst of other colored spots is intolerable. Yet the child who has learned to recognize such a spot and to have a mental picture of the United States made up of forty-eight spots, has made a good start on the way toward a useful knowledge of geography. If he goes no farther, it is to be regretted, but he has acquired ideas which will serve many a purpose. The university student who placed Lake Erie "on top of Ohio" was crude in expression, but essentially correct. Good (no pun intended) maps are now available in great variety at moderate prices and the student who is not shown something better than a patchwork of colored spots, has a right to make a vigorous protest. Suppose a school equipped with a good series of maps and the teacher proceeds to develop in the minds of the students the map idea, beginning with a clear and simple base map. Relief and drainage, temperature and rainfall, vegetation and population, soil and crops, minerals and forests, industries and communications may be added to almost any degree of detail. The map serves as a mental filing case in which every item of knowledge gained from other sources may be located in geographical order. When the student has acquired a mental picture of this composite map, and has a reasonable conception of the relations of its features to one another, he has attained that state of mind which Mr. Mackinder calls geography. This method and process is applicable to all grades from the primary to the university.

With such a standard before us, we may consider that part of the work which can or ought to be done in the high school. The position of geography in the high school is just now one of peculiar difficulty. Geography has been generally crowded out of the seventh and eighth grades, and the high school freshman is compelled to learn what he can between the ages of nine and twelve, and is left to forget what he can between twelve and fifteen. While in the grades, geography has been subjected to a systematic process of squeezing out, in the universities it has undergone expansion until geographical education has become top heavy. Twenty years ago the university teachers of geography in the United States could be counted on the fingers of one hand and the students numbered by scores. Today there are as many teachers as there were students then, and the students have become thousands. Perhaps no other institution rivals in completeness of material, personnel and curriculum the Department of Geography here at Chicago University; Wisconsin is a close second, while Yale, Harvard, Pennsylvania, Cornell, Michigan, Minnesota and Nebraska, in spite of some ups and downs, are serious and efficient. Even Hopkins, Columbia, Illinois and California have at last conceded that a subject "so elementary as geography" may not prove disgraceful. The list of summer courses in geography shows more than forty universities and colleges of high rank offering from one to fifteen courses each in geography. In spite of this, on the Brobdingnagian program of the National Educational Association at this year's meeting, geography was mentioned but once. In that vast assembly of educational forces nobody could feel more out of place than the teacher of geography. Twenty years ago the outlook for high school geography was discouraging because it led up to nothing; now it is no less discouraging because there is next to nothing leading up to it. The one hopeful thing in the situation is that teachers of geography are organizing and through their National Council will bring influence to bear for a better standing of geography in the schools. After all, school geography is what we teachers make it. It is only through us that the new geography of the universities can filter down through the high schools and normal schools to the grades. We must demonstrate to the Hegelian, Herbartian psychologist who may be president, superintendent, principal or supervisor that geography is worth as much for culture as algebra or history, and at the same time has a vocational value not much inferior to foundry practice.

The most serious strategic point in this campaign is the great gap between the sixth and the tenth grade which is likely to be filled by the junior high school. Whatever may be the claims of general science and vocational instruction to a place there, it is the duty of the geographical forces to occupy that gap in some way. The fact that we geographers are meeting here with the geologists in an earth science section indicates the belief of this Association that geography is still, as it was in the beginning, an earth science. That human existence and economy rest on a complex physical substratum, is the one lesson that geography has an exclusive right to teach. Yet perhaps we would all agree that pure physical geography in the junior grades is out of the question. It is a calamity that a single boy or girl should escape from the high school without knowing that streams make their own valleys, that by damming these valleys lakes are made, that ice sheets bring drift sheets and moraines, that rocks weather into soils, that wind transports perhaps as much material as running water, that lows and highs bring rain and cold waves, that vegetation on a sand dune is different from that in a marsh, that a 1,000 miles of lake is a better waterway than a 1,000 miles of loaded river. We teachers should be able to demonstrate the educational possibilities of these and similar physical facts and to secure a prominent place for earth science in the schools of an industrial and commercial society. Does not the fact that the one universal and deep-seated interest of humanity is not nature lore or earth lore, but economic lore—that is, how people get a living—show us a road? Can we not reach down through human wants to the one primary source of supply? Whatever the Lord of this planet provides, comes through earth, water, air and sunshine. If the geography which finds a place in the junior grades is not narrowly physical, commercial or industrial, but broadly economic, it can teach the absolute dependence upon physical environment of human life in all its phases. It can show that what we call the progress of civilization means an increasing complexity of relations between life and environment, an increasing utilization of natural resources and a corresponding expansion of the environment itself. It can show how life in the most complex of economic societies, like our own, is still dependent upon natural resources, and how a better living for the mass and the individual can come only through a wiser use of the resources of a wider environment. Such a lesson successfully taught, even in an

'elementary way, ought to satisfy the reasonable demands of education in an industrial and commercial community, reach the fundamentals of earth science and give a view of world conditions, changes and possibilities broad enough to possess the high cultural value we geographers claim for our science.

Suppose such a course to be securely installed in the junior grades, what is left for the senior? A gap there would be as lamentable as one lower down. Assuming that students may be safely turned out at the end of the ninth year with a thorough, although elementary knowledge of economic geography, what shall we try to do for the smaller but more precious number who are, in the main, to fill higher positions in the community? At a time when the world is daily growing smaller and smaller, when at every turn our convenience, our success, our safety, may depend on the possession of something from the far ends of the earth, when our environment has become all but planetary, when every human being is already our neighbor and tomorrow will be our brother, can the geographer offer anything less than the widest and clearest world view possible? Here is the place to put geography, as in Mill's famous pyramid, on a sound mathematical and physical basis. Teaching should start with crustal relief, distribution of land and water, land forms and changes, the movements of water and air, sun heat and climate, vegetative cover, plant and animal ecology, and lead up to human economy and sociology, which depend upon all the rest. In secondary instruction the mistake has been made of treating physical geography as an isolated science, regardless of the fact that its parts are unequally related to human affairs. If there are any phenomena of physiography which have little or no relation to human life, they should be left to geology, meteorology, botany or other science to which they are closely related. Only on a foundation of physical facts and principles, carefully selected, fitted and laid, can be reared the structure of a hundred halls whereof the geographer is the sole architect and master builder, the temple of regional geography. There will be Hirams of Tyre, Queens of Sheba, Kings of Arabia, and navies of Tharsish to bring cedars of Lebanon, gold of Ophir, almug trees, precious stones, ivory, apes and peacocks. Wealth and wisdom greater than Solomon's will go into it. The need and the opportunity for the higher geography was never so great as at present. Is it too much to ask and to expect that somewhere in the upper grades of the high school the student should have an

opportunity to get acquainted with the scenes, the setting, and the actors in such a world tragedy as is daily unfolding before us? Without geography, who can know what sort of a land has bred the people who hold command of the sea, and why they are willing to spend their last penny and next to their last drops of blood to maintain it? Without geography who can feel the charm of the land, to defend which a people reputed the most artistic in the world and to carry the burdens of life lightly, even to the verge of frivolity, are showing themselves capable of calm, sustained, successful effort, under the severest strain to which a great nation was ever subjected? Without geography, who can understand how, in an environment of inferior resources and almost cut off from foreign commerce, a mentally resourceful people have not been prevented by physical limitations from holding the world at bay for two years? Without geography, who can appreciate the significance of the little, rubble nations which fill the chinks in the megalithic structure of the world, Belgium, Holland, Switzerland, Denmark, Sweden, Norway, Greece, Servia, Roumania, Bulgaria, Montenegro—nations able to strive, to bear, to stand, to suffer, to fall, to do everything but die? It is largely a lack of geographic sense which renders the mass of the American people insensitive and indifferent to world events and situations, unless they happen to touch directly individual interests. The incredible provincialism of the people of New York City is due to a complete lack of sense of geographical proportion. It is largely geographic ignorance which makes the American people bungle the problems of their own internal economy, forests, waterpower, coal, petroleum, waterways, transportation, housing, immigration. The citizen who cannot rise to great questions, would like to know why bread and potatoes and shoes are dear, why dyestuffs are scarce, why by-product coke ovens are being built, why old newspapers are worth saving, why California seaweed is being harvested for potash, why an artificial nitrate plant is needed, why the brewers may abandon beer for denatured alcohol. These are questions which have become elementary in geography. Perhaps the dullest reader of the daily paper who comes up against such outlandish names as Verdun, Przemysl, Gorizia, Monastir, Dobrudja, gets a glimpse of the size and diversity of the outlandish world. It is largely through lack of adequate geography teaching that otherwise educated citizens have generally failed to recognize the value of their neighbors with

outlandish names. If our country is ever to become a melting pot instead of a scrap heap, it will be when the educated citizen learns to regard outlanders with sympathy. Sympathy grows out of knowledge and becomes effective in proportion as it is intelligent. The more the citizen knows about the environments in which his foreign-born fellow citizens have been bred, the more patience and respect will he exercise towards them.

These and similar considerations indicate that the scope of high school geography should be as broad, as deep and as high as it is possible to make it. It should not be distinctively physical, commercial or political, but regional and above all *human*. To suggest a more definite standard, it should not fall short of an acquaintance with the best textbook extant, let us say, to avoid invidious distinctions, that of Unstead and Taylor or of Andrews.

Concerning method there is little time to speak. In this day of bachelors, masters and doctors in geography, prevalent methods are good, but like morals are always capable of improvement. The trained teacher will use textbook, maps, pictures, laboratory and field according to his opportunities. Two methods need special advocacy and encouragement. First, a more varied and constant use of maps and graphic representations should be made not supplemental but fundamental, somewhat as indicated earlier in this paper. Secondly, the utmost possible extension of field work in physical, industrial and social geography can do more than anything else to tie our far-flung net of relationships to the home stakes and buoys of personal and local interest. Just now there seems to be one serious question of methods confronting us, that under the name of the project or problem method. It comes from the vocational and industrial schools, where a positive and concrete achievement, like the wiring of a door bell, or the raising of corn or chickens, involves the use of previous knowledge, and the acquirement of new knowledge and skill, and attains an interesting, practical end. The method is found to be useful in physics, chemistry and biology, and is hailed by some as a panacea for pedagogic ills, the philosopher's stone which is to transmute the teacher's lead into gold. The proposal has been seriously made to throw textbooks on the junk pile and to teach geography by a series of concrete problems. If it is the long-sought discovery, which, like the atomic theory in chemistry and evolution in biology, is to convert pedagogy into a science, geography should share in

the transformation. Problems have always been used by good teachers and might come into more frequent use with advantage, but they are only one out of many devices available under proper conditions. We have not yet found a royal road to learning. We do not know the best way to teach a child or a youth. To start a study of the British Isles with the problem, why is the British navy the largest in the world? may lead to a comprehensive understanding of British geography, but there is no evidence that this road is easier or reaches farther than the one that begins at position, area, relief and climate and ends at the great navy. Much less clearly does it follow that France or Italy or any other country is best studied in that way. Least of all does the real value inherent in the problem method, afford a basis for the assumption that it should become universal, to the exclusion of all other methods. If the teacher sees some problem which is so closely related to the life and interests of the students that it may be made their personal or common problem, and *if such a problem is capable of geographic treatment by those students*, the teacher who neglects the opportunity is indeed blind. It is one of the functions of home and field geography to furnish such problems. But the teacher who contrives problems, for the sake of problems, about fur in Canada, or chewing gum in Mexico, is no more likely to hit the mark than the one who follows a good textbook. There is no magic about tracing a chain of causal relationships backwards. Boas and muffs, thick fur, small animals, evergreen forest, cold winters, heavy snow, lakes and rivers, glaciation, granite and schist, form links in a chain no more pedagogically connected in the order given than in the reverse.

The most serious danger which seems likely to arise from the excessive use of the problem method is the loss of organization in science. In this indictment, the movement toward "general science" is also involved. The six sciences which I taught in the Fort Wayne High School in 1877 amounted to general science in the form of fourteen weeks in each science. This plan had the advantage of the present fourteen or more weeks in all science, in that it did not lose sight of distinctions. The organization of the sciences constitutes the most notable achievement of the human mind in the last thousand years. To throw away scientific organization in teaching secondary pupils is a measure as perilous as it is uncalled for. To geography it would be fatal. Its claims to the rank of an independent science, having recog-

nizable limits and logically related parts, would be abandoned. The facts involved in geography are so numerous and varied that they cannot be handled until they are clearly seen in related groups. The facts of relief and structure, the facts of temperature and rainfall, the facts of vegetation and animal life, the facts of human economy and society belong to categories so distinct that each group must be recognized for what it is before the problem of their intricate relationships can be worked out. To throw away the distinction between physical, biological and human geography is to degrade the subject from its rank as a science, to present it to the student's mind as a mass of puzzles without purpose, facts without meaning and relationships to be guessed at. It is in the relatively advanced stages of regional geography, after a sufficient physical and economic foundation has been laid, that a study of problems centered about some natural, or economic region can be most fruitful.

For us teachers of geography the duty at present most sacred is to stand fast and not be carried off our feet by the wave of "practical" and "vocational" education which is sweeping over us. It will pass and will leave the schools different from what they were before, perhaps on the whole better. This movement has its roots deep down in the geography of the richest and most complex environment on earth. The tendency is strong to produce such men as Henry Ford, who declares with amazing simplicity "I don't know anything about history and I wouldn't give a nickel for all the history in the world. The only history worth while is the history we make day by day." In the same interview he said, "I am going abroad in a couple of weeks just to get education. I am going to find out how men live in foreign countries." He appears to think more highly of geography than of history. From such men we may expect such doctrines as the "Ford idea" in education, that "*every one* should have definite knowledge of an industrial trade. It is better for character building than is intellectual training." This and similar doctrines are being forced upon the schools by financial and industrial interests, with all the pressure of imposing authority, ability and unlimited funds. The unmistakable odor of petroleum and gasoline which surrounds them should excite suspicion and caution. It is hardly possible that doctrines so revolutionary can be wholly true and that all the education of the past has been, or has become, in the progress of human development, wrong. It is not a question of Greek

*vs.* German, or Latin *vs.* Chemistry, but whether education for character and citizenship should be fundamentally materialistic, mechanical and utilitarian, or fundamentally idealistic, intellectual and humanitarian. According to Pres. Mackintosh, it involves the rough division of people into hucksters and artists, those who look upon life as a series of questions of direct profit and loss, and those who look upon it as a panorama of events in orderly and beautiful sequence. The huckster wants to learn to get a living, the artist wants to learn to live, which is a very different thing. Each has a right to be educated for his calling, but if we do not want a nation of Henry Fords, we must maintain that the pursuit and discovery of truth is as human, as practical, as vocational as the pursuit and attainment of bread and clothes, movies and automobiles, and that none of these things would now be possible, for a hundred million people, without the successful search for unadulterated truth which preceded them.

Nobody has better opportunity than the geographer for knowing whether mental training or manual training is the more valuable in getting a living, and how broad the education of the modern man of business and affairs ought to be. Perhaps if these men say to history, we will have none of you, they will say to geography, you are just what we want. This may be our opportunity to show that without geography, no adequate or correct views of economics, commerce, business, politics or current events and problems are possible, and that those who are to live in a planetary environment have need of planetary knowledge. If we can succeed in putting this proposition over on the vocational and commercial forces, we need not then forget that geography is a unique blend of the sciences of nature and of man, that it is as broad as the world and as high as humanity, that it leaves hardly any field of human effort untouched, that it can be as baldly "practical" as the commercial spirit requires, and at the same time may yield a scientific and humanistic discipline, "uncontaminated with the worship of usefulness." No other subject claims to reveal in equal variety and extent the *completion* of the world. Perhaps geography is fitted and destined to be the savior of culture from the submarines of education.

**RESEARCH IN CHEMISTRY.****Conducted by B. S. Hopkins.***University of Illinois, Urbana.*

*It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.*

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**USEFUL WEEDS.****BY GEORGE D. BEAL.***Division of Food Chemistry, University of Illinois, Urbana, Ill.*

Just as matter out of place is called dirt, so a plant out of place becomes a weed. Some of the plants which are decidedly out of place in our lawns and gardens are very much in place in localities devoted to their cultivation. The pestiferous dandelion, the yellow dock and the burdock all have their place in the *materia medica*. Many of our wild flowers are of medicinal value; the red and purple cone flowers of the roadside, the may-apple with its umbrella leaves, the bloodroot with its delicate white flowers of early spring, the blue flowering gentian of late summer, the wild geranium, senega snakeroot and many others doing their bit in healing the ailments of mankind.

Plant drugs are the oldest medicinal agents, and as a result there is a vast amount of superstition connected with their use, methods of gathering and preparation. The phase of the moon during which roots are gathered is thought by many herb doctors to determine the value or worthlessness of a drug. The shape of others is of importance.

Let me cite a few illustrations. Ginseng is used almost exclusively by the Chinese as a medicinal agent, and the forked root, resembling the human body, is deemed by them to be of far greater value than any other form. The European mandrake should also be of human form. This plant was thought to have sprung from beneath a gallows upon which a murderer had been executed, and the plant itself grew from the sweat dropping from his body. The root should be gathered during the dark of the moon, and as it screams when torn from the bosom of mother earth, it should be dragged from the ground by a dog hitched to the top, the ears of the digger being stopped with tow or wax in order that he might not hear the cries, which are certain death to the

hearer. The wild hydrangea, or seven barks, so called because it individually possesses the properties of seven other barks, is popularly believed to act as an emetic if the bark is peeled from the stem in an upward direction, but as a purgative when peeled downwards.

As a definite science of *materia medica* developed, there arose a demand for drugs which made it profitable for some people to take up the business of herb and root gathering. A few of these persons have been educated men, but the majority were ignorant backwoodsmen. As a result of this, many of the important medicinal plants which formerly were abundant in the United States have become almost extinct. The ginseng plant produces only a few seeds; these require six months for germination, and the plant must be five years old before the root is ready for use. Adding to this the certain destruction of the plant due to the fact that the root is the only medicinal part, it will be readily understood why the plant has become scarce. It is related of the Indians, who were famous herb doctors, that they gathered the plant only when the seeds had ripened, and that before digging the root they turned the top down and covered it with soil.

Miss Alice Henkel,<sup>1</sup> in an interesting series of bulletins from the Bureau of Plant Industry of the U. S. Department of Agriculture, has classified the resources of this country in native drug plants. Bulletin 107 describes over fifty distinct plants the roots of which are used medicinally, besides varieties of these species, and over half of these are recognized in the United States Pharmacopoeia, Eighth Revision, which sets the standard for drugs in this country. This number constitutes over one-half of the official root drugs. Out of the thirty-five fully described barks, twelve are official, there being altogether seventeen official barks. There are thirty-six medicinal herbs described, fifteen of them official, and thirteen flowers, fruits and seeds, with six official. It will be seen that approximately fifty per cent of the native plants to which positive medicinal properties are ascribed are regarded as so valuable that they are accorded recognition by the foremost Pharmacopoeia of the world. It may be said further that with few exceptions these plants are included in all of the important

<sup>1</sup>Bull. 89, Bureau Plant Industry, Wild Medicinal Plants of the U. S. Bull. 107, Bureau Plant Industry, American Root Drugs. Bull. 139, Bureau Plant Industry, American Medicinal Barks. Bull. 219, Bureau Plant Industry, Medicinal Leaves and Herbs. Bull. 26, Department Agriculture, Medicinal Flowers, Fruits and Seeds.

foreign pharmacopoeias, and that the United States Pharmacopoeia recognizes fewer plant drugs than does that of any foreign country.

In 1735 Collinson obtained from the Chelsea Physic Gardens in England over fifty kinds of curious seeds and began the cultivation of drug plants on a small scale. In 1789 Marshall first attempted the cultivation of the opium poppy. In gardens existing from that time, medicinal plants do not predominate, although MacMahons Garden Calendar early in the nineteenth century gives a long list of drug plants which may be cultivated.

The most extensive early cultivation of drugs was begun in the United States by the Shakers, or Shaking Quakers, in 1800, at their first community in Mt. Lebanon, New York, and taken up soon at their other villages, particularly Union Village, Ohio. At Mt. Lebanon the annual production amounted to fifty thousand pounds, which would supply the average present day manufacturer for a week. The Tilden Company, located at the same place, had about forty acres under cultivation, but the industry has completely vanished from the town now.

At the present time the cultivation of medicinal plants is being undertaken by a number of manufacturing pharmacists in an attempt to supply their requirements for certain drugs difficult to obtain of a proper degree of freshness or potency. The leaders are Eli Lilly and Company of Indianapolis, with their experimental farm at Greenfield, Ind., H. K. Mulford and Company of Philadelphia, and Johnson and Johnson, of New Brunswick, N. J. The cultivation of some plants is being carried out on an experimental scale by the Pharmaceutical Experiment Station of the University of Wisconsin at Madison, and by the College of Pharmacy of the University of Minnesota at Minneapolis. At the Wisconsin station some of the experiments have reached the stage of using acre plots.

In spite of the fact that some of our common weeds are drug plants of no mean value, the way of the gardener who seeks to cultivate them is not strewn with flowers, and as a quick money-making proposition it usually fails. There are a great many problems to be solved by the successful drug cultivator. First and foremost is the question of good seed. The sources of seed may be listed as follows:<sup>2</sup>

<sup>2</sup>F. A. Miller, *Lilly Bulletin, Series 1, No. 6* page 227.

First. Commercial samples and shipments of crude drugs. In all cases where the aerial part of the plant is used medicinally there is some opportunity for obtaining good seed. It is usually necessary to examine a number of shipments and make careful germination tests.

Second. Crude drug merchants, especially through their foreign correspondents, may be a fruitful source of supply.

Third. There may be found individuals in various countries who have interested themselves in the collection of rare seeds and plants. Some of these people are of great assistance, but others may be decidedly misinformed as to the source of their material.

Fourth. The botanical gardens form an authentic source of supply, but their collection of medicinal plants is usually small.

Fifth. Commercial seedsmen and florists have usually been found to be the best source, although the confusion of names among them leads to difficulties. Many of the medicinal plants are ornamental, which explains the reason for this source. There are, however, only a few houses which list any great variety of species.

The next problem is to determine whether or not the plant can be grown under the climatic conditions or in the types of soil available.<sup>3</sup> Serious drawbacks to the successful cultivation of many plants are the danger of winter killing of the young plants, the slow germination of the seed and growth of the young plant and the rapid growth of weeds. The Wisconsin station is considering among other problems the selection of the proper cover crop for the young plants. One of the most recently announced is winter rye as a cover for young belladonna plants. This may be made to serve a double purpose, as from the rye may frequently be obtained a supply of that valuable fungus ergot.

Another important point is whether or not the quality of the home grown drug will be equal to that of the imported drug or the wild form. It is an established fact that some drug plants lose much of their potency as a result of cultivation. Cannabis indica, or Indian hemp, was up to a few years ago obtained from India exclusively, and it was believed that the imported drug was superior to that grown in this country by reason of more favorable soil and climatic

<sup>3</sup>F. A. Miller, Lilly Bulletin, Series 1, No. 6, page 219.

conditions. The evidence obtained by experimenters in this country has been contradictory. Houghton and Hamilton<sup>4</sup> and True<sup>5</sup> have found the native drug to be equal in quality to the imported variety, while Eckler and Miller,<sup>6</sup> on the Lilly drug farm, found that the crop from the first plantings only averaged fifty per cent of the activity of the foreign drug, and that repeated plantings gave a product not over sixty-five per cent as active as the Indian drug.

The market for the drug must be such as to warrant the expenditure of much time and money in its cultivation. This makes it inadvisable for the American grower to attempt the cultivation of some easily grown drugs, or the gathering of wild forms, because of the slender market therefor.

The amount of labor required is, next to the question of soil and climate, the most important point. The labor problem is the one great obstacle to the successful production of opium in this country on a commercial scale. The amount of hand labor required is enormous, every seed capsule requiring at least two handlings.

*Belladonna* is one of the plants the cultivation of which is being taken up on an extended scale. The commercial supply has been obtained in the past from central Europe, as the *Atropa belladonna* is not a native of the U. S. Belonging to the same family as the potato and tomato, some of the problems of its cultivation are quite similar. It may be grown as an annual, when both the leaves and root are harvested, since both are used in medicine, or as a perennial, when only the top is taken. The slow germination of the seed is a drawback, six weeks being required. The seedlings must be transplanted from the seed pans to flats, which may be done by one man at the rate of fifteen hundred to two thousand plants per day, and the seedlings afterwards transplanted to the open fields at the rate of fifteen hundred per day per man. One acre will carry about forty-six hundred plants. The plants must be cultivated in the same manner as corn, and require careful watching to guard against insect pests, such as the Colorado potato beetle.

*Digitalis* is another plant grown on a commercial scale, with the same care necessary in the handling of the seedlings. The plant is a biennial, and requires much care in the har-

<sup>4</sup>Houghton & Hamilton, Am. Journ. Pharm., vol. 80, page 21 (1908).

<sup>5</sup>True & Klugh, Proc. Am. Pharm. Assoc., vol. 57, page 843 (1909).

<sup>6</sup>C. R. Eckler & F. A. Miller, Lilly Bulletin, Series 1, No. 3, page 93.

vesting of the leaves in order to prevent excessive contamination with soil which will unduly raise the ash content. A great deal of digitalis is grown in Wisconsin and Washington, but there are frequent heavy losses due to winter killing. The plant is a favorite in flower gardens, where it is known as the foxglove, and the amount grown in this country might be largely increased.

*Hyoscyamus*, or henbane, is also being cultivated, but much trouble is experienced in obtaining good seed. It is likewise a biennial, although an annual strain has been isolated. This strain has not been under cultivation long enough to determine whether or not it will have the same value as the biennial form.

Of the root drugs, *hydrastis*, or golden seal, is the one most desirable to cultivate. The root commands a very high price on the market today, but there are a number of difficulties in the way of its production. In many ways it resembles the ginseng. The seeds are few in number and slow of germination; the plant must be several years old before the root is of value and then gathering the root means the destruction of the plant; and if it cannot be grown in its native woodlands it requires an ample amount of shade, which in the usual form of drug garden is difficult to secure. Probably more success would be met with in the cultivation of the dandelion and lily-of-the-valley, which grow luxuriantly, forming large roots when the soil conditions are favorable. Other drugs which are gradually disappearing and which could probably be cultivated are the geranium, *serpentaria*, or white snakeroot, and the senega snakeroot. The last two are becoming quite rare, and attempts should be made to preserve the supply.

Peppermint, horsemint and wormwood, used for the distillation of their respective oils, can be easily grown in the northern United States, and the production of these oils is becoming quite an industry in some sections. The labor problem there is of a different type. Once a good setting of the plants is obtained in a field, the principal labor required is in the harvesting, which is done with a mowing machine, the plants being subjected afterwards to a steam distillation, which may be made in an out-of-doors still. From peppermint is marketed the oil and also its principal constituent, menthol, and from the horsemint is obtained thymol, used

so successfully in combating the ravages of the hookworm disease.

Among the bark drugs the shortage of cinchona bark for the production of quinine is the most serious. The introduction of improved methods of foresting will aid in the removal of this shortage, just as it has aided in the increase in the production of natural camphor. At present the production of cinchona bark is controlled in the island of Java, just as the natural camphor crop has been controlled in the past on the island of Formosa.

The alkaloidal content of belladonna plants has been slightly increased by a careful selection of plants for seed. Although the quality of Indian hemp grown in this country does not seem to equal in activity the foreign drug, yet there seems to have been some improvement as a result of selection. The obstacle in the way of the improved production of opium, and its production economically in the United States, is found in the fact that the formation of the opium itself from the latex of the seed capsule of the poppy is not understood. Chemical analysis of the green capsule at the time of slashing fails to show the presence of the same alkaloids that are contained in the opium in any appreciable amount.

The cultivation of medicinal plants will not prove to be an easy pursuit for the small landholder. A great deal of labor will be required, and for some time the returns will be small. The person seeking to enter this business should first of all take the matter up with one of the manufacturing pharmaceutical houses using these drugs, some firm of drug millers, or with the Bureau of Plant Industry at Washington. These will gladly place at his disposal all of the available information on the subject, and will usually be in a position to aid him in obtaining good seed, roots or cuttings, and can also put him in touch with the proper markets. There is a recognized shortage in the supply of drug plants, and serious efforts to aid in relieving the condition will be welcomed. Half-hearted or hysterical attempts to engage in the production of these drugs, will, however, meet with discouragement, and rightly so, for such attempts, only ending in failure, will tend to discourage those who can make a success of the business.

**RESEARCH IN PHYSICS.****Conducted by Homer L. Dodge.**

*State University of Iowa, Representing the American Physical Society.*

*It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be nontechnical, and it is hoped that they will furnish material which will be of value in the classroom. Suggestions and contributions should be sent to H. L. Dodge, Department of Physics, State University of Iowa, Iowa City, Iowa.*

*The Nature of Matter and Electricity*, by Daniel F. Comstock and Leonard T. Troland,<sup>1</sup> should be read by every teacher of physics or chemistry. This is a strong recommendation but its unqualified form is intentional for, during the past summer, we have been reading the book with pleasure and profit and are certain that it would meet with favor with the readers of this journal.

The work attempts to give in broad, schematic form the conception of the structure of the material universe which has developed in the minds of modern students of physical science. All the salient general ideas have been touched upon. That this has been accomplished in a scholarly way in a book which is non-mathematical and popular in character is noteworthy.

Part I, written by Dr. D. F. Comstock, formerly professor of physics in the Massachusetts Institute of Technology and now a consulting engineer in Boston, gives a general sketch of the fundamentals of the modern theory. Of the twenty-one sections we found ourself most interested in those dealing with the structure and behavior of atoms. Professor Comstock has evidently given much thought to the matter of making the kinetic theory readily apprehended. His explanations of "How Friction Causes Heat" and "Why Evaporation Cools" are by far the most satisfying that we have seen. After reading this part of the book we remarked to an acquaintance upon the simplicity and clearness with which the author presented new and involved theories. To our surprise the acquaintance proved to have been a student of Professor Comstock and we learned that he had always taken a special delight in discovering simple ways of explaining the complicated subject matter of physics. In fact, he had often on long walks talked over with this student many of the subjects treated in the book, thus testing out their clarity of presentation.

Part II, written by Dr. L. T. Troland of Harvard University, consists of fifty-six sections, each of which discusses in detail some problem more briefly treated in Part I. Many of its sections are calculated to answer the question, "How is it known to be so," which is often asked when the astonishing results of physical investigations are recounted. Several of the methods for determining the size and shape of atoms are described. The periodic table and the dependence of the atomic properties on atomic weight and atomic number are discussed. The various theories of the atom and its part in molecular structure are taken up in detail, as well as all of the important discoveries regarding the electron and the phenomena of radioactivity.

A brief quotation will show the nature of the subject matter and treatment better than further comment. The following is from the section on "The Discovery and Measurement of the Electron."

"The electron was discovered by J. J. Thomson as the result of a series

<sup>1</sup>D. Van Nostrand, New York, \$2.00.

of epoch-making and very ingenious experiments. When an electrical discharge passes through a tube from which the air has been partially exhausted it consists, in part, of a beam of rays which seem to be emitted from the negative pole, or "cathode," of the battery or induction coil. Thomson showed that these so-called "cathode rays" are made up of very minute bodies nearly two thousand times lighter than hydrogen atoms, and moving at a speed which varies with conditions but which is in general about one-tenth that of light, or about twenty thousand miles a second.

Thomson did not determine the size of the electron directly but only its weight, or more strictly speaking its mass. This he was able to do by use of the well-known principle that the more massive a body is, and the higher its velocity, the greater is the resistance which it offers to change in its state of motion. It was found that the cathode rays could be bent by the action of a magnet, a fact which showed them to bear electrical charges, and by measuring the magnitude of this bend as compared with the strength of the magnet employed, a basis was provided for the calculation of the mass of the moving particles. Measurement of the bend of the rays under the influence of magnetism alone did not permit Thomson to separate the effect of the speed at which the particles were traveling from that due to their mass, but by studying the bend which occurred when electrical as well magnetic forces were brought to bear upon the rays, he was able to obtain a measure which depends upon these mass and not upon the velocity of the particles.

However, it unfortunately happened that these measures were not independent of the electrical charge borne by the single particles and consequently he was obliged to devise a method for the determination of this charge. The method which he actually used consisted in a simple measurement of the total amount of electricity carried by a large number of the particles, followed by a determination of the number itself. From these two measurements the quantity of electricity carried by one particle could obviously be calculated.

Thomson's procedure for finding the *number* of articles corresponding to a known charge was exceedingly clever. On account of its charge, each of the particles is a center of forces of attraction, so that if they exist in an atmosphere over-saturated with moisture, this moisture tends to condense about the individual particles, each of the latter thus becoming the nucleus of a small drop of water. The size of the drops of water thus formed can be determined by the rate at which the fog which they compose settles under the pull of gravity. Since it is easy to measure the total amount of water which condenses, the number of droplets in the fog can be calculated from a knowledge of their individual size. Since each droplet corresponds to a single electrical particle the number of droplets gives a measure of the number of such particles which are present, and hence permits the calculation of the charge which they individually bear.

Knowing the amount of electricity carried by each particle in the cathode rays, it is possible to separate the effect of the charge from that of the mass, and hence to ascertain the magnitude of the latter. The most refined measurements of this sort show that the cathode ray particles, which are now called *electrons*, have a mass which is about one eighteen-hundredth that of the lightest known atom, hydrogen.

## Seventeenth Meeting of the Central Association of Science and Mathematic Teachers

Attention! Forward march! to Columbus, Ohio, November 30 and December 1, 1917.

Come and help make the next meeting of the Central Association of Science and Mathematics Teachers the biggest and best.

*No teacher can afford to teach this year as he did last.* He must teach faster and better. Conservation is the national slogan and Conservation in education is the most important kind. The nation needs, as never before, that education which will conserve the powers and abilities of its boys and girls.

It is the patriotic duty of every member of the Association to attend the meeting and make himself a more efficient teacher. It is the patriotic duty of every teacher of science and mathematics to join this largest and most progressive Association of its kind in the country, in order that he may fit himself to help eliminate educational waste.

The H. C. of L. necessitates retrenchment, but that should be along the line of avoiding waste and in making personal sacrifice, not professional. It is no economy to sacrifice efficiency in education.

Our experience in this war has forever changed the nature of the American government. Likewise, it has changed the purposes, methods, and subject matter of our teaching.

Dr. W. O. Thompson, of Ohio State University, will talk on the general theme of the convention, "Immediate and Ultimate Aims in Science Teaching." Dr. Thompson is a vital speaker, who always has a message.

"The Science Element in Education" will be the subject of the address to be given by Dr. L. H. Bailey of Cornell University. There has never been a time when science so universally affected the lives of men as it does now.

Each Section of the Association has prepared not only interesting but practically helpful programs. Space does not permit individual mention. However, it should be noted that the Ohio Home Economics Association meets jointly with our Home Economics Section, and that conservation will be the keynote of the program, with Mr. Croxton, Food Administrator for Ohio, as one of several attractive speakers.

One session of the Agriculture Section will be devoted to General Science, and all teachers of this subject are cordially invited.

To know all the good things in store for you at our Thanksgiving feast, read the program. Programs will be mailed about November 1. If one fails to reach you, send your name and address to the President, Miss E. Marie Gugle, Assistant Superintendent of Schools, Columbus, Ohio, or to the Secretary, Professor A. W. Cavanaugh, Lewis Institute, Chicago, Ill.

Members from Chicago and the West should join the party leaving Chicago, over the Pennsylvania Railroad, Thanksgiving night, November 29, and arriving in Columbus at seven o'clock Friday morning. Make your reservation for this train through the chairman of the Transportation Committee, Mr. Willis E. Tower, Englewood High School, Chicago.

The meetings will be held at the Ohio State University, whose campus and buildings are unusually attractive at all times, but which has an added feature of having one of the big aviation schools of the country in operation at this time.

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#### ARTICLES IN CURRENT PERIODICALS.

*American Journal of Botany*, for October; *Brooklyn Botanic Garden, Brooklyn, N. Y.*; \$5.00 per year; 60 cents a copy: "Taxonomic Characters of the Genera Alternaria and Macrosporium," John A. Elliott; "Crown-rot of Fruit Trees: Histological Studies," J. G. Grossenbacher.

*American Mathematical Journal*, for September; 5548 Kenwood Ave., Chicago; \$8.00 per year: "The Presentation of the Notion Function," Joseph A. Nyberg; "Directed Angles and Inversion, with a Proof of Schoute's Theorem," Roger A. Johnson; "A Simple Relation between Elementary Number Theory and Elementary Projective Geometry," Aubrey J. Kempner; "Concerning Preferential Voting," L. L. Dines.

*Geographical Review*, for September; *Broadway at 156th St., New York City*; \$5.00 per year, 50 cents a copy: "Between the Tigris and the Indus," Colonel Sir Thomas H. Holdieh; "The Homes of Blindfishes," Carl H. Eigenmann (10 photos, 4 diagrs.); "The Traveling Doctors of the Andes: The Callahuayas of Bolivia," G. M. Wrigley (1 map, 5 photos); "Island Nantucket," C. F. Brooks (1 map, 3 diagrs.); "The Role of Political Boundaries," D. W. Johnson; "The Passing of the Fahrenheit Scale," Alexander McAdie (1 diagr.).

*Journal of Geography*, for September; *Madison, Wis.*; \$1.00 per year, 15 cents a copy: "Calendar Reform," Frederick Homburg; "Teaching Commercial Geography," Charles A. Daly; "Crude Sugar Making in China," Walter N. Lacy; "Influence of the Gulf Stream," "Geographies of the Eighteenth Century," Albert Earley; Geographical Material on South America: "Latin America and the War," "Conditions in Peru," "Vegetable Ivory," "The Platinum Supply of Colombia," "Santos and Sao Paulo."

*Journal of Educational Psychology*, for September; *Baltimore, Md.*; \$3.00 per year, 35 cents a copy: "Some Causes of Misspellings," Arthur W. Kallom; "The Education and Control of the Emotions," T. S. Henry; "The Weighing of Point Scale Tests," Rose S. Hardwick;

"An Annotated Bibliography of Recent Literature on the Binet-Simon Scale (1913-1917), Part I," Samuel C. Kohs; "Manual Accuracy in Prevocational-School Boys," Russell L. Gould.

*L'Enseignement Mathematique*, for May; G. E. Stechert & Co., 151 West 25th St., N. Y.; 15 francs per year, 2 francs a copy: "Sur quelques representations arithmetiques des fonctions analytiques," A. Kienast; "Sur certaines fonctions analytiques uniformes obtenues comme limites de fonctions uniformes," D. Pompeiu; "Notions d'arithmogeometrie," E. Turriere.

*Nature Study Review*, for September; Ithaca, N. Y.; \$1.00 per year, 15 cents a copy: "The Common Butterflies," Anna Botsford Comstock; "A Color Key for Butterflies"; "Some Disguises of the Mourning Cloak," Harriet A. Wiekwire; "Some Familiar Butterflies," R. W. Shufeldt; "The Chrysopas or Golden Eyes," Roger C. Smith; "A Funny Family," Wm. D. Funkhouser.

*Photo Era*, for September; Boston, Mass.; \$2.00 per year, 20 cents a copy: "Burson & Condit—Mail-Order Men," Michael Gross; "A Method to Test Shutter-Speeds," R. V. Wilson; "Direct Positives on Bromide Paper"; "Nature-Faking with the Camera," Ralph Osborne; "Making a Skeleton Darkroom," T. R. Church; "Men Whom a Woman Dreads to Photograph," Grace Cox Rutter; "Landscape-Photography," V. Akers.

*Physical Review*, for September; Ithaca, N. Y.; \$6.00 per year, 60 cents a copy: "On a General Expansion Theorem for the Transient Oscillations of a Connected System," John R. Carson; "The Stark Effect in Helium and Neon," Harry Nyquist; "The Ionization Potential of Electrodes in Various Gases," F. M. Bishop; "Internal Relations in Audion-Type Radio Receivers," Ralph Bown; "Distribution of Potential in a Corona Tube," Harry T. Booth; "The Effect of Strain on Heterogeneous Equilibrium," E. D. Williamson; "Demagnetization of Iron," Arthur Whitmore Smith; "The Electrical Conductivity of Sputtered Films," Robert W. King; "The Mercury-Arc Pump; The Dependence of Its Rate of Exhaustion on Current," L. T. Jones and H. O. Russell.

*Popular Astronomy*, for October; Northfield, Minn.; \$3.50 per year: "Why the Axes of the Planets are Inclined," William H. Pickering; "The Observatory of Silla, with Plate XVII," W. Carl Rufus; "The Birth of a Planet—II," N. Johannsen; "American Ephemeris Tables of Rising and Setting of Sun and Moon," Albert S. Flint; "In Limine," C. E. Barns; "The Stupendous Smallness of Our Earth," Charles Nevers Holmes; "Twenty-first Meeting of the American Astronomical Society, with Plates XVIII and XIX"; "Stations for the Solar Eclipse of June 8, 1918," Harold R. Baker.

*Popular Science Monthly*, for September; 239 4th Ave., New York City; \$1.50 per year, 5 cents a copy: "Operating on Trees," "Hurling Barbed Wire at the Enemy"; "The Ben Franklin of Today"; "Air-Propelled Unicycle"; "Food for the Taking"; "Scientific Laboratory Two Miles in the Air"; "All Around a Battle Ship"; "Measuring the Wear of Roads"; "Practical Motor Boating"; "Wireless Work in Wartime."

*School Review*, for September; University of Chicago Press; \$1.50 per year, 20 cents a copy: "The Junior College as an Integral Part of the Public-School System," Alexis F. Lange; "A Criticism of Recent Attempts to Measure Language Ability," Baker Brownell; "Scientific Program-Making in the Central High School at Grand Rapids, Michigan," Alice M. James.

*School World*, for July; Macmillan and Company, London, Eng.; 7s. 6d. per year: "The Paradox of Style: The Teacher's Problem," J. H. Fowler; "Day Continuation Schools," Charlotte M. Waters; "New Languages and Their Place in the School Curriculum," E. Allison Peers; "The Teaching of Science in American Schools," Hilda J. Hartle; "The House of Education and Its Work."

## PROBLEM DEPARTMENT.

Conducted by J. O. Hassler,

Crane Technical High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions. All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. In selecting solutions for publication we consider accuracy, completeness, and brevity as essential. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.

## Algebra.

521. Proposed by S. L. Quinby, Antioch, Cal.

Two players sit at solitaire, each with a pack of 52 cards. Each deals himself a hand of four cards. "A" showing his hand remarks, "I have the ace of hearts." "B," doing likewise, replies, "I also, have an ace." Required, the probability that each of the players holds another ace.

Solution by A. M. Waas, Philadelphia.

A (or B) in the three cards remaining in his hand must have one, two or three of the remaining aces in the remainder of the pack. There are 51 cards from which the three may be chosen and

$$\frac{51 \cdot 50 \cdot 49}{3 \cdot 2 \cdot 1} = 20825.$$

Hence, there are 20825 ways to choose a hand that must contain a certain ace.

It is evident that only one of these combinations can contain three aces. Since three things may be taken two at a time in three ways, there are three combinations of two aces at a time. With either of these there might be taken either one of the 48 cards not aces.  $3 \times 48 = 144$ . Also, there are three ways of taking one ace at a time and with each one there are  $4 \cdot C_2 = 1128$  ways of choosing the other two cards.  $3 \times 1128 = 3384$ .

Since  $1 + 144 + 3384 = 3529$ , one, two or three aces will appear in a three card combination of 51 cards 3529 times. The chance for an ace then in either A's or B's hand is  $3529 / 20825$ .

Since these are independent events, the probability that each holds an ace is the product of their separate probabilities.

$$\frac{3529}{20825} \cdot \frac{3529}{20825} = \frac{12453841}{433680625} = \frac{1}{35}, \text{ approximately}$$

There were two incorrect solutions of this problem.

522. Proposed by Daniel Kreth, Wellman, Ia.

Solve the equation,

$$x^2 + x + \sqrt{x} = 22.$$

Solution by R. M. Mathews, Riverside, Cal.

Let  $y = \sqrt{x}$ , and the proposed equation becomes:

$$y^4 + y^2 + y - 22 = 0.$$

The possible rational integral roots are  $\pm 1, \pm 2, \pm 11, \pm 22$ .Of these  $y = 2$  verifies ( $\therefore x = 4$ ) and the depressed equation is the cubic,

$$y^3 + 2y^2 + 5y + 11 = 0.$$

Since the signs are all positive, there are no positive roots.

Trial locates a root between  $-2$  and  $-3$ , and shows  $-3$  as a lower bound for the roots. This root between  $-2$  and  $-3$  is  $-2.106 \dots$ . Therefore,  $x = 4.436 \dots$ , with proper regard for the negative value for the root when checking in the original equation. Use of Sturm's Functions on the equation in  $y$  shows that there is only this one negative root, and that the other two are imaginary.

There were two incorrect solutions for this problem.—Editor.

### Geometry.

**523. Proposed by R. T. McGregor, Nord, Cal.**

ABCD is a parallelogram. From any point E on AB a line is drawn parallel to AD meeting DC in F. From any point G on AD a line is drawn parallel to AB meeting BC in H and EF in K. Show that the following lines are concurrent; the joins of A and H, C and E, D and K.

I. *Solution by Elmer L. Hunting, Canisteo, N. Y.*

Let the intersection of EC and GH be M, and that of DK and AB be N.

In triangles KEM and HMC,  $\angle KME = \angle HMC$ , and  $\angle MEK = \angle HCM$ .

$\therefore \triangle s$  KEM and HCM are similar.

$\therefore KM:MH :: EK:CH$ .  $KF = CH$ .  $\therefore KM:MH :: EK:KF$ . (1)

Similarly in  $\triangle s$  ENK and GKD.

$EK:GD :: EN:GK$ .  $GD = KF$ .  $GK = AE$ .

$\therefore EK:KF :: EN:AE$ . (2)

From (1) and (2).  $KM:MH :: EN:AE$ .

$\therefore$  DK, AH, and EC are concurrent (intercepting proportional segments on two parallel lines).

II. *Solution by Murray J. Leventhal, New York City.*

Select axes of coordinates so that the following points have the coordinates indicated: A, (0, b); B, (0, 0); C, (a, 0); D, (a, b); E, (0, c); H, (d, 0); K, (d, c). The equations of AH, CE, DK are, respectively,

$$bx+dy-bd=0,$$

$$ex+ay-ac=0,$$

$$x(c-b)+y(a-d)-(ac-bd)=0.$$

These lines are concurrent since the eliminant obviously reduces to zero.

**524. Proposed by N. P. Pandya, Sojitra, India.**

Two tangents to a circle intersect and then pass through points A and B, respectively, outside the circle. If the points A and B and the length of the chord of contact are known, is it possible to determine the circle?

I. *Solution by Mabel G. Burdick, Stapleton, N. Y., and R. M. Mathews, Riverside, Cal.*

No, the circle is not determined by the given parts.

Draw any two lines Ay and Bx, respectively, from A and B, intersecting at P. Let PT be the bisector of  $\angle APB$ . Let PR be the perpendicular to PT and equal to one-half the given chord, and a parallel to PT through R cut Px (or Py) in K. Let the perpendicular to Px (or Py) at K cut PT in O. With center O and radius OK describe a circle. This circle satisfies the given but is not determined, since Bx and Ay are not determined.

*There was one incorrect solution to this problem.—Editor.*

### CREDIT FOR SOLUTIONS.

520. L. E. A. Ling. (This should have been acknowledged in last issue, but was overlooked.—Ed.)

521-524. Acknowledged with the publication of the solutions on the preceding pages.

### PROBLEMS FOR SOLUTION.

#### Algebra.

**536. Proposed by Daniel Kreth, Wellman, Ia.**

Five gamblers, A, B, C, D, E, play together on the condition that he who loses shall give to each of the others as much as he already has. First A loses, then B, then C, then D, and finally E. At the end of the fifth game each has \$32. How much had each before they began to play?

**Geometry.**

**537. Proposed by Nelson L. Roray, Metuchen, N. J.**

Equilateral triangles are constructed outwards upon the sides of any triangle. Prove by elementary geometry only that the given triangle and the triangle whose vertices are the outermost vertices of the equilateral triangles have the same median point.

**538. Proposed by N. P. Pandya, Sojitra, India.**

Construct a triangle ABC, having given angle B, median from C on AB, and the angle between the median and the perpendicular from A on BC.

**539. Proposed by Sam I. Jones, Nashville, Tenn.**

Given an angle and a point without its sides to draw through the point a line cutting the sides of the angle, forming a triangle whose perimeter equals the length of a given line.

**540. Proposed by Daniel Kreth, Wellman, Ia.**

Construct the triangle if the three radii of the escribed circles are given.

**SCIENCE QUESTIONS.**

Conducted by **FRANKLIN T. JONES,**  
*University School, Cleveland, Ohio.*

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.

**Acknowledgment.**

The receipt of examination questions is gratefully acknowledged from E. A. Stewart, Gilbert, Minn., and Dr. L. C. Newell, Boston University.

**Questions and Problems for Solution.**

**279. Proposed by John C. Packard, Brookline, Mass.**

Can a real image be formed by the action of a plane mirror? [Suggestion—Consider the use of a plane mirror in connection with the reflectoscope.]

**280. Proposed by A. Haven Smith, Riverside Junior College, Riverside, Cal.**

A cylindrical shaft 4 inches in diameter, weighing 80 lbs., turns without friction about a horizontal axis. A fine cord is wrapped around it by which a 20-lb. weight hangs. How long will the weight take to descend 12 feet?

**281. Submitted by Philo F. Hammond, University of Alberta, Edmonton South.**

[The EDITOR suggests a careful comparison of the following examination paper with the College Entrance Examination Board paper published in October, 1917, SCHOOL SCIENCE AND MATHEMATICS.

Which is the easier? Which more nearly represents the attainment desired in pupils of high school age?

Is thinking in terms of mathematical relations (emphasized by the Board) more natural to the student of high school age than thinking in terms of verbal description (emphasized by Alberta)? Which is more desirable from a pedagogical point of view?

Are our efforts at teaching young students mathematical physics wisely expended?

Is it unpedagogical to teach physics in such a way that pupils will like it? Do they like mathematical physics?

*Please discuss these papers freely and send in your comments.]*

HIGH SCHOOL AND UNIVERSITY MATRICULATION EXAMINATIONS BOARD,  
UNIVERSITY OF ALBERTA.

MATRICULATION EXAMINATION, MAY, 1917

**PHYSICAL SCIENCE.** Time—*Two and one-half hours.*

1. (a) What are the chief characteristics of wave motion?  
 (b) Distinguish transverse and longitudinal waves.  
 (c) Explain the terms condensation and rarefaction as applied to sound waves.
2. (a) Define wave-length.  
 (b) How may the wave-length of a note produced by a tuning fork be measured?  
 (c) Given a tuning fork of known vibration frequency, how may the velocity of sound in air be determined experimentally?
3. (a) Describe any common method of determining the vibration frequency of a note.  
 (b) Four steel wires, A, B, C and D, having the same diameter and length, are stretched on a sonometer and made to vibrate. If the tension of A is 4 pounds, what must be the tensions of B, C and D, if the vibration frequencies of the notes produced bear to one another the same relation as those of a major chord.  
 (c) What is the relation between the pitch of the fundamental note of a closed organ pipe and that of its first and second overtones?
4. (a) Describe an experiment to show that a material medium is necessary for the transmission of sound.  
 (b) Why do the box of a sonometer, the sounding-board of a piano and the cone or horn of a phonograph increase the intensity of the sound?
5. (a) In what respects does a magnet differ from a magnetic substance?  
 (b) Explain fully each of the following phenomena:  
   (1) A compass needle freely suspended takes approximately a north and south position.  
   (2) The axis of the needle makes an angle of varying magnitude with a geographical meridian as it is moved in an easterly or westerly direction.  
   (3) If the needle is suspended at its centre of gravity it takes an oblique position with the north-seeking pole pointing downward.  
   (4) Retort stands and the iron parts of desks tend to become magnets.
6. (a) Describe experiments to show that there are two kinds of electrification.  
 (b) Write a note on the distribution of an electric charge on (1) a sphere; (2) a cylindrical body with rounded ends; (3) an irregular body.  
 (c) Describe any common electrical condenser and show how it may be charged and discharged.
7. (a) Describe, giving drawing, any economic voltaic cell and state the method used of preventing polarization.  
 (b) Show by means of a simple experiment that a wire through which a current of electricity is passing is surrounded by a magnetic field.  
 (c) On what conditions does the strength of an electro-magnet depend?
8. (a) Describe experiments showing the conditions under which an induced current may be produced.  
 (b) Write a note on the direct current dynamo or the electric motor naming the parts and stating their functions.  
 (c) What transformation of energy takes place in the dynamo?

9. (a) Describe the construction and action of a telephone receiver.  
 (b) State the use of the induction coil or transformer in the telephone circuit.
10. Describe the construction and operation of the transmitter and receiver of a simple wireless telegraphy apparatus.  
 OR
11. (a) Describe the method of producing Rontgen Rays.  
 (b) State their more important properties and uses.

**SOLUTIONS AND ANSWERS.**

267. *Proposed by Robt. W. Boreman, Parkersburg, W. Va.*

In a given calcium solution which would cause the more complete precipitation of Ca, the addition of fluoride ion until its concentration is 0.1 mole per liter, or the addition of the carbonate ion until its conc. is 0.1 mole per liter?

*Solution by R. W. Boreman.*

Solubility of  $\text{CaF}_2$  is 0.0163 g. per liter. Its molar solubility is therefore  $0.0163 \div 78 = 0.00021$ . Its solubility product is  $0.00021 \times (0.00042)^2 = 3.7 \times 10^{-11}$ .

Solubility of  $\text{CaCO}_3$  is 0.0110 grams per liter. Its molar solubility is therefore  $0.0110 \div 100 = 0.00011$ . Its solubility product is  $0.00011 \times 0.00011 = 1.2 \times 10^{-8}$ .

Let  $x$  = Conc. of the  $\text{Ca}^{++}$  when the  $\text{F}^-$  has a conc. of 0.1.

Then  $x \times 1^2 = 3.7 \times 10^{-11}$  or  $x = 3.7 \times 10^{-8}$ .

Let  $y$  = conc. of  $\text{Ca}^{++}$  when the  $\text{CO}_3^{2-}$  has a conc. of .1.

Then  $y \times .1 = 1.2 \times 10^{-8}$  or  $y = 1.2 \times 10^{-7}$ .

There is therefore about 300 times as much Ca left in the solution when carbonate is used as when fluoride is used for precipitation under the same conditions.

268. *Proposed by C. T. Beach, Tunkhannock, Pa.*

A painter was working on a staging hung by a block and tackle from a painter's hook that rested on a projecting cornice of the building. The rope was, as usual, tied to the staging. On lowering the staging, he passed an iron rod sticking out of the wall, and tied the free end of the rope to the rod. The cornice promptly broke. Why?

*Solution by J. P. Drake, Emporia, Kan.*

When the rope is fastened to the apparatus the pull on the cornice is the weight of apparatus, but when the rope is fastened to the rod in the wall there is added to the above pull a force equal to the pull on the rope.

271. *Proposed by Niel Beardsley, Bloomington, Ill.*

Given a single movable pulley. One rope is fastened to the ceiling. A man stands on the pulley and pulls upward on the other rope. How much must he pull to just balance? Can he lift himself?

*Solution by J. P. Drake.*

$$\frac{\text{wt.} + F}{2} = F \quad \therefore F = W.$$

Therefore, neglecting friction, weight of pulley and rope, a man can balance himself by lifting his own weight.

No. 244 bobs up again in No. 271. The above is probably the shortest solution.

273. *Submitted by Philo F. Hammond, University of Alberta, Edmonton South.*

The Extension Department of this University received a request from a secondary school in Alberta Province for a method of determining the constant,  $k$ , in the formula,  $F = k \frac{m_1 m_2}{d^2}$ , as applied to universal gravi-

tation. The Ontario High School physics gave 0.000,000,064, 8 dynes as the attractions between two small spheres, each weighing one gram, if placed one centimeter apart. How was this result obtained?

*Solution by J. P. Drake. Also solved by P. F. Hammond.*

$$F = k \frac{m \times m'}{d^2}.$$

Consider the attraction between 1 gm. mass and the earth, then  $F = 980$ . Find value of  $m'$ , the weight of earth, in grams, and radius of  $e^2$  in cm., and then  $k = .000,000,064 \pm$ .

Using this value in the formula,  $F = k \frac{m \times m'}{d^2}$  when  $m = 1$ ,  $m' = 1$  and  $d^2 = 1$ , weight  $F = k$ .

$\therefore$  the force in dynes = .000,000,064  $\pm$ .

For Cavendish's & Boys' method of finding  $k$  and then the mass of the earth, see *A Text-Book of Physics*, Duff, p. 102.

#### SOME PLEASANT FACTS.

The first Liberty Loan of 1917 was a great success in whatever aspect it is considered. The government called for two billion dollars and over three billion dollars was subscribed for by more than four million people. This large subscription and this great number of subscribers were obtained, after a short campaign, from a nation that as a people were not accustomed to purchasing government bonds. The spirit with which vast numbers of citizens and organizations worked to make the loan a success is not an unimportant element in making the loan not merely a success but a triumph.

It should be remembered, too, that the bond issues of other nations were sold when the foe was either on their territory or at their very gates. Our bonds were sold when danger was far from us. There was no duress, there was no hysteria, and there was but little war spirit. The bonds were bought in the calm exercise of patriotism and sound business judgment after a campaign of education and information.

Richmond, Va., the old capital of the Confederacy, bought a Liberty bond for every five inhabitants. Montana, in the far West, largely exceeded its quota of bonds. Little villages all over the country exceeded their quotas as did also the metropolis of the country. There was hardly a State, city, or community that did not do the same. Poor crop conditions, a recent great fire, and other local causes resulted in two districts falling a little below their allotments, but the large oversubscription everywhere else more than made up for this unavoidable deficiency. Cities with large foreign-born populations subscribed as liberally as others.

The united spirit of the American people, the solidarity of the Nation, made up as it is of people from all nations, have been demonstrated.

A second loan is now on. The same things that made the initial loan of two billion dollars a success will operate to make the new one equally successful. In fact, the information regarding government bonds and finances now possessed by the people of the country will make the placing of this issue of bonds less difficult. Those subscribers of the first issue who were not allotted their full subscription will give the new issue a start of more than a billion dollars, since it may be regarded as certain that they will not lose the opportunity to obtain the amount of government bonds desired.

## TWO USES FOR GRAPHS.

BY WILLIAM SLEATOR,  
*Ann Arbor, Mich.*

## 1. CURVES FOR LENS AND MIRROR PROBLEMS.

The relations between object distance, image distance, and focal length of a lens or a mirror are usually brought home to the student by the examination of special cases. For example, he is asked to locate the image formed by a convex lens when the object is at the principal focus, or at a distance between the focal length and twice the focal length. If numerical results are required, use is made of an equation of the form

$$\frac{1}{q} - \frac{1}{p} = \frac{1}{f},$$

where  $q$ ,  $p$ , and  $f$  represent the distances, measured from the lens, of image, object, and principal focus, respectively. By this formula any number of particular examples may be worked out, but it appears that even many special cases may leave a student without a grasp of general relations, that is to say, unable to anticipate approximately the result of a calculation.

As in many similar instances, a graphical method suggests itself, as presenting in accessible form the results of all possible problems, and here the suggestion is particularly fortunate. It seems best to take rectangular coordinates, to represent  $q$ , the image distance as the ordinate;  $p$ , the object distance as abscissa; and to use  $f$  as a unit of measure.  $p$  is always to be considered positive it is measured from the lens or mirror toward the source of light. With these conventions one may, by separate solutions of appropriate equations, obtain data to plot a curve for convex lenses, one for concave lenses, one for convex mirrors and one for concave mirrors.

But it may be remembered that the lens equation  $\frac{1}{q} - \frac{1}{p} = \frac{1}{f}$  is obtained from considerations quite general, holding for convex as well as concave lenses, the difference being, in fact, that  $f$  is to be considered positive for concave and negative for convex lenses. So in the substitution of

numerical values the above equation applies to both cases.

Similarly, in the equation for spherical mirrors,  $\frac{1}{q} + \frac{1}{p} = \frac{1}{f}$ ,

$f$  is positive for concave and negative for convex mirrors, and the one equation serves for problems on either sort. Then if  $f$  is used as a unit of measure in the graphs for both lenses and mirrors, one curve should do for both kinds of lenses, and one for both kinds of mirrors. For we can change the sign of  $f$  by interchanging the plus and minus signs conventionally assigned to the two sides respectively of a coordinate axis.

We might now proceed to assign values to  $p$ , solve for  $q$ , and plot our curves, and perhaps for practical purposes this is what we should do. But it is interesting first to consider either equation—say  $\frac{1}{q} + \frac{1}{p} = \frac{1}{f}$ , for lenses—from the standpoint of algebra. If it be cleared of fractions we have

$$pf - qf = pq, \text{ or}$$

$$(a) \quad pq + qf - pf = 0.$$

This equation, being of the second degree, represents a conic section—in fact, an equilateral hyperbola whose asymptotes are parallel to the axes. Its center, located by the equations

$$\begin{aligned} p + f &= 0 \\ q - f &= 0 \end{aligned}$$

is at the point  $p = -f$ ,  $q = f$ . If we subtract  $f^2$  from both members of (a) it becomes  $pq + qf - pf - f^2 = -f^2$ , or by factoring

$$(b) \quad (p + f)(q - f) = -f^2.$$

This equation might often be used in place of

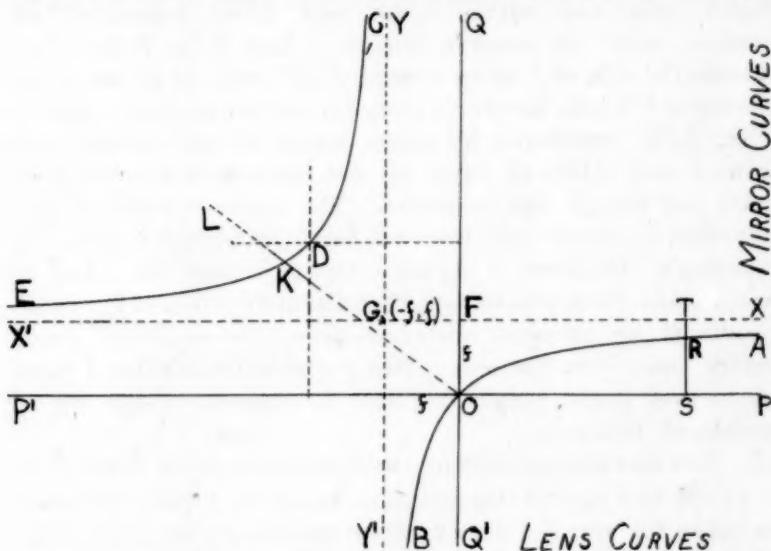
$$\frac{1}{q} + \frac{1}{p} = \frac{1}{f}$$

To proceed further, we put  $x = p + f$ ,  $y = q - f$ , and have

(c)  $xy = -f^2$ , an equation which represents the same hyperbola, referred to axes through its center. The two branches lie in the second and fourth quadrants in the  $x, y$  system, and they pass through the points  $p = 0$ ,  $q = 0$ , and  $p = -2f$ ,  $q = 2f$ . The figure shows the curve. For concave lenses  $f$  is positive and  $OP$  and  $OQ$  are positive. Also, since  $p$  is essentially positive, only the branch  $ORA$  has a physical meaning, and all problems possible in our

field concerning concave lenses have their graphical solution in that branch of the curve.

Similarly, since for convex lenses  $f$  is negative, we are to regard  $OP'$  and  $OQ'$  as positive. Since the object distance is always positive, the curves  $OB$  and  $EKC$ —continued indefinitely—tell the whole story for this class of lenses. Thus it appears that for a concave lens  $q$  is always positive; always, except when  $p$  is infinite, less than  $f$ ; and always,



except when equal to 0, less than  $p$ . For convex lenses  $q$  is positive always and only when  $p$  is less than  $f$ . When positive, it is, except when equal to 0, greater than  $p$ . If  $p$  is greater than  $f$ ,  $q$  is negative; it is  $-2f$  when  $p = 2f$  (at the point D) and approaches  $-f$  as  $p$  approaches infinity, becoming itself infinity when  $p = f$ . It remains to be noted particularly that all cases where the image is virtual are represented by the branch AOB, and all those concerning real images by CDE.

If drawn with precision on cross section paper, these curves give approximate numerical answers to problems. For example, if for a concave lens  $f$  is + 12 inches and  $p$  (necessarily plus) 36 in., (FT),  $q$  is + 9 inches (SR). Similarly, if for a convex lens  $f$  is - 10 inches and  $p$  5 inches,  $q$  is + 10 inches. If we know that a certain lens forms a real image 30 cm on one side of an object 40 cm on the other,

we may draw a line OL, and it appears from the coordinates of the point K that  $f = -17.1\text{cms}$ .

One might now proceed similarly with the equation  $\frac{1}{q} + \frac{1}{p} = \frac{1}{f}$  for mirrors. But this differs from the lens equation only in the sign of  $1/p$ , and is symmetrical with respect to  $p$  and  $q$ . If now we turn the figure through  $90^\circ$ , so as to regard OP as the negative image axis and OQ as the positive object axis, the curves ORA and EDC represent all possible cases for concave mirrors. And if, as before, we reverse the sign of  $f$ , so as to regard OP' and OQ as negative, the curve OB tells the whole story for convex mirrors. Moreover, AOB represents all cases where virtual images are formed and CDE all cases of real images, *this association being just what it was for lenses*. The representation of lens relations by curves has been set forth before—it is given in Nutting's "Outlines of Applied Optics," page 32. And it has, I think, been pointed out that a simplification of formulae results if we measure distances from the principal focus rather than from the lens. But perhaps the outline I have given may prove suggestive, and an example of the use of graphical methods.

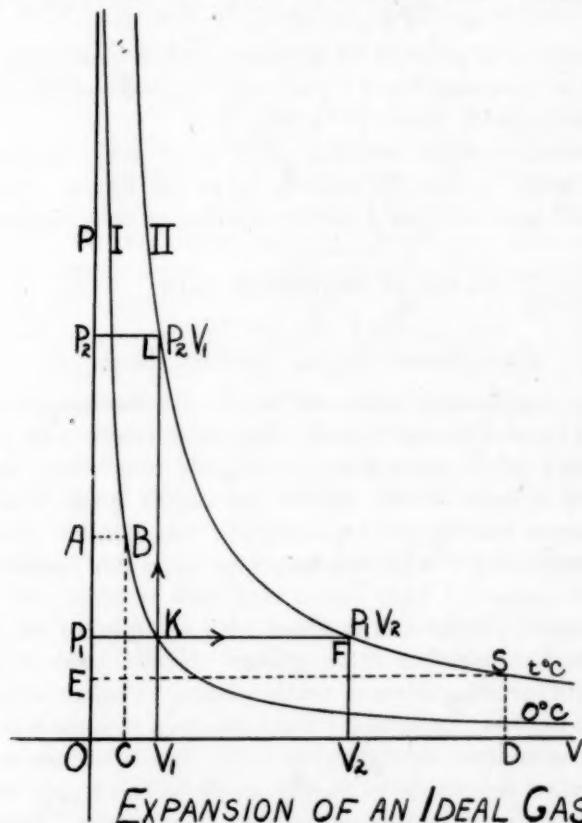
## II. THE REPRESENTATION OF THE EXPANSION OF AN IDEAL GAS.

In the first part of this article an equation already obtained or taken for granted was examined graphically in order to set forth the solutions of ordinary problems concerning lenses and mirrors. This illustrated an important use of graphical methods. However, they may often aid us in understanding a proof or derivation. In this second part I wish to follow through by diagram the proof that the pressure coefficient and volume coefficient for a perfect gas are equal; that is, that  $a_v$ , the coefficient of pressure change—defined by the equation  $P_t = P_o (1 + a_v t)$ , where the subscript  $v$  represents constant volume—equals  $a_p$  the coefficient of volume change—defined by the equation  $V_t = V_o (1 + a_p t)$ , where the subscript  $p$  represents constant pressure.

We will represent as usual the pressure as the ordinate and the volume as the abscissa in a rectangular system. Then any possible state of a constant mass of gas kept at a constant temperature—say  $0^\circ\text{C}$ —is defined by some point on the rectangular hyperbola I, and every point on that curve represents a possible state of the gas. This follows

from Boyle's Law. For the several points of the curve the areas of such rectangles as ABCO are equal.

Now, suppose the body of gas is at the pressure and volume  $P_1$  and  $V_1$ , given by the point K, and let it be heated to some new temperature,  $t^\circ\text{C}$ , keeping the volume constant. The line KL represents this process, and L lies on a new hyperbola II, which represents all states of the gas at  $t^\circ\text{C}$ , just as I represents states at  $0^\circ\text{C}$ . The coordinates of L are  $P_2$ ,  $V_1$ . Next let us suppose the gas returned to the state given by



K, and then again heated, keeping the pressure constant, to the same temperature  $t^\circ\text{C}$ . KF represents this process, and F lies on the hyperbola II through L, since II represents all possible states of the given mass of gas at the new temperature. Then the two rectangles whose vertices are L and F are equal by the nature of the hyperbola so that

$$P_2 V_1 = P_1 V_2.$$

Now by those equations which defined  $a_p$  and  $a_v$ , namely,  $P_2 = P_1(1 + a_v t)$  and  $V_2 = V_1(1 + a_p t)$ , we have  $P_1 V_1(1 + a_v t) = P_1 V_1(1 + a_p t)$  so that  $a_p = a_v$ . In words, the change in pressure per unit pressure per degree ( $a_p$ ) equals the change in volume per unit volume per degree ( $a_v$ ). One thing more may be pointed out. Obviously, from what has been said any rectangle defined by II, as ESDO, is the product of any rectangle defined by I, as ABCO, and  $(1 + a t)$ , so we may write

$$(PV)_t = (PV)_0 (1 + a t),$$

or in words, the product of pressure and volume (*any pair*) of a gas at temperature  $t$  equals *any* corresponding product at temperature 0, times  $(1 + a t)$ .

This note contains nothing more than may be found in any textbook, except the references to the figure. But perhaps these may aid one's understanding of this fundamental proof.

#### GENERAL SCIENCE AGAIN.

By E. A. STRONG,

*State Normal College, Ypsilanti, Mich.*

I have been greatly interested in the discussions which have appeared from time to time in SCHOOL SCIENCE AND MATHEMATICS and other educational periodicals concerning the form which the science of the eighth (or ninth) grade shall take. This interest has led me to engage in considerable conference and correspondence with teachers who have this instruction in hand. In general I have found that such teachers are, as one would expect, pretty well satisfied with the system which they have adopted, whether it be general science, project science, agriculture, or some form of earth science. Project science has seemed a hard saying to many teachers, even to some who habitually use a method strongly akin to it. Earth science or physiography has been able to justify itself in the hands of many teachers who have had regard to the experience and interests of their pupils rather than to the subject matter as given in any particular text. And so for agriculture, which, as given by many teachers, does not differ greatly from courses given in other schools under the name of general science or physiography. But especially do the advocates of general science in the eighth grade feel that they have made out a good case and find great satisfaction in their solution of this question.

I have myself been more impressed by this satisfaction in the course chosen than in the reasons given for it. For example, it seems rather puerile to insist, as is often done, that general science is only a continuation of the nature study of the grades below and is not science in any good sense; or to urge that these eighth grade pupils are studying plants and not botany, the stars and not astronomy, etc. The lesson—or the series of lessons—is the thing, and not the name given it. The pupils themselves are not so unsophisticated. If their text does not tell them all they want to know about plants, stars, etc., they resort promptly to some botany or astronomy in their high school library to help them out.

Then it is not easy to see why most of the arguments in favor of science in the eighth grade do not apply equally well to the grades above and below the eighth, especially where a six-and-six division is followed, either really or nominally. I say nominally, since it happens not infrequently that the seventh and eighth grades are simply called high school grades without any change from the old four-and-four system, either in course of study, texts, method, or faculty. There should be some science—some study of occupation and environment—in all grades of a public school. All along the line pupils should be encouraged and helped to study their world as a preliminary to the study of the great world around them, and the value of this study will depend upon the community interest in this world and the vitality of the relation between the community and the school as expressed in the teachers and the course of study. All systems will work well if they are well worked.

This consideration makes me willing to suggest another system which has not, I think, received due consideration, yet is the almost universal method of continental Europe. For example, the plan of studies of a French lycee might be followed, simply adapting it to the purposes of American education. Such a plan does not contemplate, it will be remembered, five lessons a week in four subjects of study, as is still with us the almost universal custom, especially in our smaller high schools, but rather a course for each grade, including all subjects of study demanded by the general purpose of the school, by logical sequence, and the present and life interests of the pupils, each having space according to its importance. Some subjects may be omitted for a term; some may have assigned to them a single lesson, or two, or three, a week; some perhaps have a daily

lesson. For example, you conceive that pupils in the eighth year of school life should have some study of machines; very well, give them two lessons a week during the winter. All the easily seen planets may be observed in the early winter evenings; very well, give to their study a lesson a week for the year. In these lessons previous study and experience will be reviewed and incorporated with the new observation and experiment.

Our difficulty lies partly in the attempted tandem instead of this more or less parallel arrangement of the numerous subjects of study demanding admittance into a modern school. Nothing is more characteristic of American scientific education than the habit of postponing all consideration of a subject until a late hour, pressing it constantly and with all vigor for a while, and then dropping it forever. We seem to have the greatest distrust of an extended course, running perhaps through several years, now interrupted, and now given in one or more lessons a week as striking examples arise in the experience of pupils or the ongoing of nature. And yet in many practical subjects well-planned work of this sort may have high value and significance.

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#### AN OPEN LETTER TO CHEMISTRY TEACHERS.

A second Chemistry Show is to be held in Columbus, Ohio, in connection with the Thanksgiving meeting of the Central Association of Science and Mathematics Teachers. The exhibit is designed to bring before the high school chemistry teachers the newest aids and devices for the teaching of the science.

There was exhibited at the meeting last year material of the following character: charts, pictures, books, specimens illustrating industrial processes, new experiments in action, results of experiments, lists of special topics, novel apparatus and laboratory devices, advertising literature.

Please bring or send to the meeting as much of this kind of material as possible—also anything else even if not listed. Do not fear that your material is insignificant. If it has been helpful to you it will be helpful to others. Urge it upon every chemistry teacher you know and try to get manufacturers and publishers to help us.

The committee appointed last year by the Chemistry Section of the Central Association intend to get out a descriptive catalog; so get in touch with the chairman at once in order that your exhibits may be properly listed and credited. Remember that any material which is useful is not insignificant.

The material to be listed in the descriptive catalog must be in the hands of the committee not later than November 15.

Address your communication to Miss Jessie Caplin, Chairman of the Committee, West High School, Minneapolis, Minn.

**THOSE NOTEBOOKS.**

BY LOYD C. ELLIOTT,

*High School, Phoenix, Arizona.*

Watson leaned back in his chair, looked at his watch, and then sized up the pile of physics notebooks that still remained to be graded.

"This notebook grading makes me tired. What's the use of it anyway?" he mused. "It doesn't help the student to remedy his errors. He doesn't know a whit more, except, perhaps, that he got 76 on his notebook. It means a lot of time and work for me. It looks as though the efficiency of this business is about 10 per cent or less."

In the next few days Watson did some thinking, with the result that now he is never found working on a pile of notebooks. He has dispensed with that.

When I dropped into his room the other day he was seated at his desk. John had brought his notes of experiment 10 and was waiting while Watson examined them.

"John, is this 47 dogs, chickens, or sheep?"

"Why, it's pounds, Mr. Watson."

"All right. Put it on. Also all those other units you left off."

Next came Fred with his notes.

"Very good, Fred. Put them on the pile," and Watson checked up that experiment to Fred's credit on his record chart.

George brought his notes.

"You've been too careless in doing this experiment, George. Your results are away off. You'll have to do it again. Better get a start on it right away."

And so it went. After the class was gone, I asked Watson to give me the details of his method.

"Well," said he, "I have done away with the notebooks and use simply the loose leaves. As fast as each student completes his notes of the experiment he has done, he brings them to me and waits while I examine them. I make no attempt to read all he has written. I simply glance them through looking for the main points. Anything that is wrong or poorly done, I have him correct. If necessary, I have him repeat his work. When satisfactory, I have him place the sheets on a pile, which I remove at the end of the day. These I keep till the end of the year, when the student may have them if he desires. As soon as I have accepted his notes I check him off on my chart.

The chart is cardboard, about 2x3 feet or smaller. I cross-section it into centimeter squares, with the students' names at the left and the experiment numbers at the top. In checking off the experiments I use three marks: + for notes better than the average; X for average notes, and - for notes poorer than the average but yet acceptable. From these marks it is easy to make up a grade. Say, I want a grade for 6 weeks during which 10 experiments have been done. I call the -, 75; the X, 85; and the +, 95. If a student has 10 X's, his grade is 85. If he has a mottled record, I get his grade by the excess above or below the average of 85. If he has four +'s, four X's, and two -'s, his two low marks would cancel two of his high marks and he would have left an excess of two high marks above the average. His grade would then be 87. If he had one +, two X's, and seven -'s, his excess would be six -'s below average and his grade would be 79. It's all very flexible. One could assign different values to the marks if he so desired."

"That sounds pretty good, Watson, but I'd think you might have a rush along about the end of the hour when a good many were finishing up their notes at the same time."

"Sometimes I do, but the ones I do not get to understand that they are to hold their notes till next time and bring them to be checked in then."

"How does it work out?" I asked.

"Fine. It gets results. I have the student right here to show him what's wrong. He tries harder to have things right in the first place. Then, too, I know right where each student is. He can't get away behind or write up a lot of bad notes and I not find it out till the end of the term or semester."

I left Watson's room that day convinced that he was on the right trail.

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#### PORCELAIN ELECTRICAL SUPPLIES SHOW LARGE INCREASE.

The value of porcelain electrical supplies marketed in the United States in 1916 was \$7,034,420, an increase of \$2,363,218 over 1915, according to the United States Geological Survey, Department of the Interior. These wares were reported from ten States, of which Ohio was the leader, reporting wares to the value of \$2,181,026. New Jersey was second, with \$1,674,093, and New York, third, with \$1,623,433. These three states reported 78 per cent of the value of the entire output.

The Merriam Co., Springfield, Mass., publishers of Webster's International Dictionary, have just issued a very interesting little booklet, "Dog-Day Club," which will be sent free on request. "Dog-Day Club" is a story of a summer picnic charmingly told. It contains many hints of value for those getting up children's parties.

#### THE SCALE ON A MAP.

Distance on a map is measured by its "scale." By laying a rule on a Government map and ascertaining the number of inches between two points, the number of miles between them can readily be calculated. Nearly all maps are drawn to a scale representing one, two, three, or more miles to the inch, as the inch is the common unit of measurement in the United States by which the eye is accustomed to judge distances on paper.

A scale of 1:62,500, used in the well-known United States Geological Survey topographic maps, denotes that 1 inch on the map represents 62,500 inches on the ground, which is the approximate number of inches in a mile. Therefore, the scale is, almost exactly, 1 inch to 1 mile. A scale of 1:125,000 is approximately 2 miles to 1 inch, and a scale of 1:1,000,000 represents 16 miles to 1 inch.

#### MOLYBDENUM.

An important use for molybdenum growing out of the European war was developed from the discovery that it is the most efficient stabilizer for unstable high explosives such as cordite, melinite, and the like. It has long been understood that the Japanese used it extensively in the manufacture of their smokeless powder, shimose, but the credit for the discovery of its most recent field of usefulness as a stabilizer must be accorded to the chemists of France, who worked out its application to this branch of munition making since 1914.

The research work of an American chemist, Dr. F. A. Fahrenwald, of the Case School of Applied Science at Cleveland, has, however, opened up fields of unsuspected usefulness for both molybdenum and tungsten far surpassing in scientific interest and probably also in commercial value their use in the steel-making or munitions industry. Dr. Fahrenwald was employed three years or more ago by the Research Fund of the American Dental Association to discover, if possible, a practical substitute for the rare and costly metal, platinum.

More than one-third of the world's annual supply of platinum is consumed in dental work, and its tremendously accelerated cost had almost reached the point of prohibition to the dental profession, platinum having been worth for the past two years or more in the neighborhood of eighty to one hundred dollars an ounce, or four or five times the price of gold.

To summarize in a single sentence Dr. Fahrenwald's incomparably valuable research work, it may be said that he has conclusively demonstrated that either tungsten or molybdenum (and preferably an alloy of the two metals), treated in the electric furnace by metallurgical processes discovered by himself, affords a completely adequate substitute for platinum, not only in dentistry, but also in many other branches of industrial art, such as the manufacture of contact points for spark plugs, electro-thermic couples, and many other devices.—*Mining American*.

**FOSSIL OCEANS OF GREAT AGE.**

Among the many unsolved mysteries concerning the interior of Mother Earth few are more fascinating than those brought to light by certain surprising experiences of drillers of deep wells. Although many people are not aware of the fact, a large proportion of the wells sunk to depths below 1,000 feet encounter large bodies of salt water, the flow of which may be so great that the driller remarks that he has struck the Gulf of Mexico or some other immense body of salt water. The salt water may even flow up out of the mouth of the well, but more commonly it rises in the well to a height of several hundred feet above the bottom, and its supply is so great that only a pump of enormous capacity can keep the well empty. Where does this salt water come from? It is often assumed that it fills some immense cavity or system of crevices, but in fact it is generally contained in some bed of unusually porous rock, like sandstone, in which the pores, though minute, have an aggregate volume or capacity of millions of cubic feet.

But one question is no sooner answered than another one, more difficult, arises, and the question now is, How did this salt water get into the porous rock? Has rain water soaked far down in the earth and found some bed of rock salt which it dissolved and thereby become salty; or had the salt water some source far within the earth from which it has arisen toward the surface; or is it the water of some ancient ocean that filled the pores of sand and mud of its bed, which in ages gone by became buried under sand and mud that gradually accumulated on the ocean bottom? The shells of sea animals found in limestones and other hard rocks at the heart of the continent show clearly that the ocean, in some one or several remote ages, covered a large part of the country, and it appears extremely probable that the salt water found in the deep wells is really fossil sea water entombed in the sands and muds of former eons and now brought to the surface by the drill, which in innumerable places in this and other countries is being sunk to depths of two, three, and four thousand feet, and even down to depths of nearly 7,500 feet, a depth reached by a very deep well which is still being drilled at a place a little west of Pittsburgh.

This salt water seems to be found especially in oil fields, but it has been struck by the drill at many other places, as, for example, near Leavenworth, Kans., where enormous quantities of salt water are found at various depths below the surface. Although no valuable pools of oil or gas have been found in that region, numerous beds of coal underlie it. In one boring four beds of coal aggregating over 8 feet in thickness and numerous thinner beds having an additional total thickness of 6 feet were found. In that region also many outcropping layers of rock contain remains of marine shells, and the entire region was no doubt once covered by the sea. Indeed, the geologist has been able to decipher in the rocks numerous details of the record of the advance and retreat of the sea and has been able to establish the fact that the region was submerged at several different times. These and other geologic features of the region near Leavenworth, Kan., and east of it, in Missouri, including its mineral resources, are described in a folio of the Geologic Atlas of the United States just issued by the United States Geological Survey, Department of the Interior. This folio, the Leavenworth-Smithville folio (No. 206), which was prepared in cooperation with the Missouri Bureau of Geology and Mines, contains also geologic maps and numerous other illustrations. It may be obtained by sending 25 cents to the Director of the Survey.

**RUSSIA'S FOREIGN TRADE IN 1916.**

European Russia imported \$545,853,000 worth of goods in 1916, an increase of no less than 100 per cent over the total for 1915. Last year's imports fell only \$83,000,000 short of the figure for the normal year 1913. As a matter of fact, since the official figures do not include munitions, the value of the goods actually received and requiring transportation must have been greatly in excess of the value recorded.

When it is considered that in 1916 European Russia received goods by two routes only (Archangel and Scandinavia-Finland), while goods were entered at forty-four ports in 1913, it is easier to appreciate the tremendous freight traffic that the port of Archangel and the Russian railroads were called upon to handle and the inevitable congestion that has made necessary the strict limitation of imports.

The most important contributors to the Russian market in 1916 were the United Kingdom and the United States. An extraordinary increase over 1913 (4,735 per cent) was made by Japan, whose energetic canvass of foreign markets since the war started has attracted attention in Russia, as well as in South Africa and Australia. In relative increase over 1913 the United States takes second place, the percentage being 252.

As might be expected, the articles imported in largest quantities were those directly or indirectly connected with the war. Machinery and apparatus, the largest item in value (\$39,508,000), represented only 28 per cent of the quantity imported in 1913, but 40 per cent of the value. The United States and the United Kingdom were the sources of the largest machinery imports, their respective shares in 1916 being 27,000 and 23,000 tons.

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**THE LIBERTY LOAN AS A NATIONAL FORCE.**

The first liberty Loan of 1917 already constitutes an important factor in our national life. It has given a new direction to thought among the people and a new impulsion to popular aims. The effects of the loan on the government, on the body of the people and on the individual citizen of the United States are sure to be great and manifold.

The four million holders of Liberty Loan bonds will look with more care and attention on financial legislation by Congress than heretofore. Much of the national indifference to alleged extravagant and unwise legislation will vanish so far as they are concerned. The direct, individual, financial interest which every bond holder has in the government's finances will make each an active and effective agent for economy in administration and for wise legislation.

The Liberty Loan is going to create a new voting force in the body politic—a civic force in which partisanship and extravagance are to be subordinated to better and wiser things.

The Liberty Loan's influence for good, in another way, is going to be largely effective through its influence on the individual bond holder. To thrift for one's own sake there has been added the incentive for thrift for the nation's sake. Thrift for the nation's sake will benefit the individual and combine two strong motives—Patriotism and self-interest.

Economy like extravagance is more or less infectious. We are just passing through an era of extravagance and entering on a period of economy. The Liberty Loan furnished an inspiration and an opportunity for economy and saving.

As the intolerable humiliation of owing to Germany the war indemnity in 1870 made the French people a nation of savers and government bond buyers, so the great Liberty Loan of 1917 with its call upon the patriotism of Americans will make this nation more a nation of savers than ever before.

The number of subscribers to the loan and the amounts subscribed make the two billion dollar loan more than a success. It was a triumph and its effect on the people of America will be far reaching and lasting.

#### **THE LIBERTY BONDS AND THE FARMER.**

It has been repeatedly pointed out that in purchasing Liberty Loan bonds the farmers of the United States were furnishing the means to their best customers to purchase the products of their farms. Much of the proceeds of the Liberty Loan, both that used by the United States Government and the amount loaned to the Allies, is to be expended in purchasing food and supplies for their armies from the farmers of the country. There are other reasons, however, that make the Liberty Loan bonds especially desirable investments for farmers.

A safe investment is particularly suited to a farmer because he is, in most instances, at a distance from bond markets and not in position either to know of or immediately act upon information of matters affecting the value of bonds. The Liberty Loan bonds are invincibly safe, backed as they are by the resources of the richest nation in the world and the faith and credit of a people who have always respected their obligations, and they are of stable value and liable to little or no fluctuations in market value. The farmer is a busy man, and often has neither the time nor the opportunity to study the questions of finance and bond values. The Liberty Loan bond being a bond about which there can be no question, he can rest assured always that he has made no error in judgment.

The farmer often feels the need of ready cash before the harvesting of his crops. The Liberty Loan bond puts in his hand a security on which he can always borrow money and at a rate as low or lower than he could borrow on any other security and with less trouble.

There is another aspect of this investment in Liberty Loan bonds that will appeal to every true American. He is supporting the Government, he is supporting our soldiers in France, and he is doing his duty as a citizen when he invests in Liberty Loan bonds.

#### **A PEOPLES' WAR.**

"The great fact that stands out above all the rest is that this is a peoples' war, a war for freedom and justice and self-government amongst all the nations of the world, a war to make the world safe for the peoples who live upon it and have made it their own, the German people themselves included; and that with us rests the choice to break through all these hypocrisies and patent cheats and masks of brute force and help set the world free, or else stand aside and let it be dominated a long age through by sheer weight of arms and the arbitrary choices of self-constituted masters, by the nation which can maintain the biggest armies and the most irresistible armaments—a power to which the world has afforded no parallel and in the face of which political freedom must wither and perish."—[Woodrow Wilson, President of the United States.]

**HANDY HOMEMADE ATOM MODELS.**

By W. J. BRAY.

*State Normal School, Kirksville, Mo.*

Since the well known forms of atom models of German make are no longer to be had, American teachers of chemistry are forced to make other arrangements for that valuable form of illustrative material. The writer has for some time been using atom models, made, under his direction, by a class in ceramics. The models were moulded out of clay with one, two, three four, five or six clay projections as desired. These projections were designed to illustrate the valence of the atom. When all of the models needed had been carefully moulded, they were fired in the furnace. They were then glazed, different colored glaze being used to illustrate the different kinds of atoms.

In using these models we use short pieces of rubber tubing to connect the projections or valences; thus molecule models can be readily built up. This is a very inexpensive set, and one which we have found to be quite satisfactory in actual use. We have been using it for about four years.

**UNITED STATES FOOD ADMINISTRATION.**

In planting its campaign the Food Conservation Bureau of the United States Food Administration has realized the importance of the public school as a medium for the dissemination of the ideas which are "to modify the food habits of the one hundred million of our people." It has therefore sought the cooperation of state universities and colleges in order to have the food conservation program reach as large a number of students as possible. A ten-lesson course in conservation was prepared by a committee of domestic science experts, among whom the Department of Agriculture, the Bureau of Education and the United States Food Administration were represented.

In addition to giving the ten-lesson course to summer schools, teachers' institutes were asked to aid in the work. Letters were written to state superintendents, to presidents of state universities and agricultural colleges, and county commissioners, and to each of these a food conservation syllabus was sent. Replies to date have shown enthusiastic cooperation. During the first week there were requests for 28,000 copies of the lessons for institutes held during August, and requests since then have more than doubled that number.

With a realization of the enduring need of a conservation program on a broad and fundamental basis the United States Food Administration is planning, with the cooperation of the Bureau of Education to place in the schools a course of study which shall be incorporated not as an emergency measure, but as a permanent problem and integral part of our freshened educational aims.

The Bureau of Education will therefore publish on the first of each month up to June, a bulletin of family and civic economics. The material will be in the form of reading and study courses for elementary and high school grades, and will cover all the topics that enter into community life. These lessons are intended to stimulate closer co-operation between the school and the community in general in solving the problems of our democracy.

## BOOKS RECEIVED.

*Everyday Physics, A Laboratory Manual*, by John C. Packard High School, Brookline, Mass. Pages vi +136. 61 exercises. 20x27 cm. Cloth. 1917. Ginn and Company, Boston.

*Abstract of the Census of Manufactures, Department of Commerce*. 722 pages. 16x23 cm. Cloth. 1917. 65 cents. Government Printing Office.

*Mortality Statistics for 1915, Department of Commerce*. 707 pages. 24x31 cm. Cloth. 1917. Government Printing Office, Washington.

*McIntosh Stereopticon Co., Catalogue S of Slides*. 63 pages. 15.25x22.75 cm. Paper. 1917. Free. Chicago.

*A Textbook of Mycology and Plant Pathology*, by John W. Hershberger, University of Pennsylvania. Pages xiii +779. 14x20 cm. Cloth. 1917. \$3 net. P. Blakiston's Son and Co., Philadelphia.

*The Illinois Survey*, L. D. Coffman, Director. 377 pages. 14x20 cm. Cloth. 1917. The Illinois State Teachers' Association, Springfield.

*Third-Year Mathematics for Secondary Schools*, by Ernst R. Breslich, University High School, the University of Chicago. Pages xviii +369. 14x20 cm. Cloth. 1917. \$1.00. The University of Chicago Press.

*Logarithmic and Trigonometric Tables and Mathematical Formulas*, by Ernst R. Breslich, University High School, the University of Chicago. Pages xvii +118. 14x20 cm. Cloth. 1917. 75 cents. The University of Chicago Press.

*A Textbook of Botany for Colleges*, by William F. Ganong, Smith College. Part II. Pages ix +341—595. 14x20.5 cm. Cloth. 1917. \$1.00. The Macmillan Company, New York.

*Rural Textbook Series, Soils and Fertilizers*, by T. Lyttleton Lyon, Cornell University. Pages xx +255. 13x19.5 cm. Cloth. 1917. \$1.10. The Macmillan Company, New York.

*School Entomology*, by E. Dwight Sanderson and L. M. Peairs, West Virginia University. Pages vii +356. 13.5x20 cm. Cloth. 1917. \$1.50 net. John Wiley and Sons, New York.

*Elementary Mathematical Analysis*, by John W. Young and Frank M. Morgan, Dartmouth College. Pages xii +548. 13x19 cm. Cloth. 1917. \$2.60. The Macmillan Company, New York.

*Infinitesimal Calculus*, by F. S. Carey, University of Liverpool. Pages xiii +144 +v. Cloth. 1917. \$1.80. Longmans, Green and Co., New York City.

*Outlines of Comparative Anatomy of Vertebrates*, by J. S. Kingsley, University of Illinois. Pages x +449. 16x23 cm. Cloth. 1917. \$2.50 net. P. Blakiston's Son & Co., Philadelphia.

*Projective Geometry*, by L. W. Dowling, University of Wisconsin. Pages xiii +215. 13x19 cm. Cloth. 1917. \$2.00. McGraw-Hill Book Co., New York.

*Problems in General Physics for College Courses*, by Morton Masius, Worcester Polytechnic Institute. Pages vi +90. 13.5x21 cm. 1,000 problems. Cloth. 1917. 90 cents. P. Blakiston's Son & Co., Philadelphia.

*German Science Reader*, by Frederick W. Scholz, Columbia University. Pages xii + 462. 13x19.5 cm. Cloth. 1917. \$1.10. The Macmillan Company, New York.

*High School and College Textbooks; Descriptive Catalogue with price list*. Pages xxxvii +456. 13x19 cm. Cloth. 1917. American Book Company, Chicago.

Elementary Principles of Economics, by Richard T. Ely, University of Wisconsin, and George R. Wickes, Dartmouth College. Pages xv+446. 13x19 cm. Cloth. 1917. \$1.10. The Macmillan Company, New York.

Yearbook of the United States Department of Agriculture for 1916. 783 pages. 15x23 cm. Cloth. 1917. Government Printing Office, Washington.

An Experiment in the Fundamentals of Education, by Cyrus D. Mead, University of Cincinnati. Pages xiv+54. 12x18 cm. Paperboard. 1917. 60 cents. World Book Co., Yonkers, N. Y.

Proceedings of the High School Conference, 1915, University of Illinois, by Horace A. Hollister, Editor. 356 pages. 15x23 cm. Paper. The University of Illinois, Urbana.

National Service Handbook, by Committee on Public Information. Pages x+246+5 maps. 14.5x23 cm. Paper. 1917. Government Printing Office, Washington.

The Carnegie Foundation for the Advancement of Teaching; Eleventh Annual Report of the President and Treasurer. 172 pages. 18.5x25.5 cm. Paper. 576 Fifth Ave., New York City.

Negro Education in the United States, prepared under the direction of Thomas J. Jones, Bureau of Education. 18.5x25 cm. Vol. I, xiv+423 pages. Vol. II, v+724 pages. Paper. Vol. I, \$1.00. Vol. II, \$1.25. Government Printing Office, Washington.

Sixth Biennial Report, State Superintendent of Public Instruction, Oklahoma, for 1916. 252 pages. 15.5x23 cm. Cloth. Oklahoma City.

Arithmetic Tests and Studies in the Psychology of Arithmetic, by George S. Counts, Delaware College. Pages iv+127. 17x24 cm. Paper. 1917. 75 cents +postage, wt., 11 oz. University of Chicago Press.

Development of Arithmetic as a School Subject, by Walter S. Monroe, Kansas State Normal School. 170 pages. 15x23 cm. Paper. 1917. 20 cents. Government Printing Office, Washington.

Seventeenth Annual Report of the Director of Education, Philippine Islands. 131 pages. 18x25.5 cm. Paper. 1917. Bureau of Printing, Manila, P. I.

The Electron, by Robert A. Millikan, The University of Chicago. Pages xii+268. 13x19 cm. Cloth. 1917. \$1.50 +postage. The University of Chicago Press.

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For copies in good condition of Vol. 2, No. 3, May, 1902, we will allow 30c on subscription or 25 cents cash.

For Vol. 1, No. 2, April, 1901, we will allow 50 cents.

## BOOK REVIEWS.

*Experiments in Educational Psychology*, by Daniel Storch, University of Wisconsin. Pages ix+204. 13x19 cm. 2nd edition. Paper. 1917. \$1.00. The Macmillan Company, New York.

A splendid book for use in experimental psychology. No elaborate apparatus is needed when this manual is used. The experiments are simple and for many of them the material is contained in the book itself. There are 16 chapters which are not necessarily dependent on each other, except chapters v and vi. The book is in its second edition. There are many charts and tables. It is printed on uncalendered paper; thus the glare of too much reflected light is avoided. Major paragraphs begin with bold face type. The style is clear and to the point. Mechanically, it is well made and will stand wear.

C. H. S.

*Laboratory Manual for Introduction to Science*, by Bertha M. Clark, William Penn High School for Girls, Philadelphia. 203 pages. 19.5x24.5 cm. Loose leaf. Paper. 1917. American Book Company, Chicago.

A manual worthy of adoption into the laboratory of general science in any high school. This collection of 100 exercises is from the results of actual practice in this school for several years. The exercises have been selected for their worth in illustrating principles and fixing them in the mind of the pupil. The large number of exercises gives the teachers range in the choice of work, thus adapting the work to both city and country schools. The scheme of reporting results by the pupils saves his time as he reports directly on the experiment sheet. The plan of procedure is: statement of problems; apparatus to be used; directions for operation; observations; conclusion and discussion. The questions in connection with each exercise are a very valuable feature. The manual will doubtless have a wide adoption.

C. H. S.

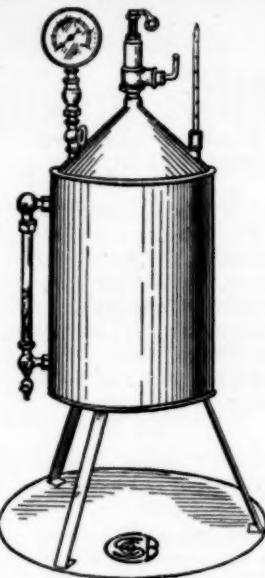
*Laboratory Lessons in General Science*, by Herbert Brownell, University of Nebraska. Pages xi+215. 13.5x19 cm. Cloth. 1916. 80c. The Macmillan Company, New York City.

This book is made up of a series of laboratory exercises to accompany any good text in general science. The author has drawn from his long experience in teaching secondary school science those exercises which will enable the pupil to best grasp the subject in question and at the same time stimulate in him a desire for the study of science. It is written in a clear, readable, and teachable manner. Many new and helpful suggestions are found here. There are ninety well-selected drawings and figures. The experiments cover the range of subjects usually taught in a general science course. There are seventeen chapters. These chapters are divided into lessons, the major paragraphs in the lessons being numbered for easy reference. There is an appendix of a list of apparatus, with cost, used in the book. There is appended, too, a list of references helpful in this study. There is a good index of three double column pages. The book is mechanically well made. It deserves a very extensive sale.

C. H. S.

*Laws of Physical Science*, by Edwin F. Northrup, Princeton University. Pages ix+210. 13.5x20 cm. Limp leather. 1917. \$2.00 net. J. B. Lippincott Company, Philadelphia.

A book which will be welcomed by all persons who have occasion to use the mathematical expressions illustrating the physical laws. No such elaborate compilation has ever appeared in book form.



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The author has conferred upon physicists and engineers a most valuable favor in producing this book. The book is of convenient size and weight. It is divided into six sections: mechanics; hydrostatics, hydrodynamics and capillarity; sound; heat and physical chemistry; electricity and magnetism; light. In general, the law is always stated in words and where possible the mathematical expression is given; reference to standard texts is given in connection with the discussion of each law. There is a bibliography of books to which reference is made and also a very complete index of sixteen pages. It is printed on uncalendered paper, thus reducing reflection to a minimum. Mechanically, it represents the highest skill in the book-makers' art.

C. H. S.

*Vocational Mathematics for Girls*, by William H. Dooley. Pages vi+369. 13x19 em. 1917. D. C. Heath & Co., New York.

This is one of the best books on vocational mathematics that the writer has seen. It is offered as an introduction to the regular secondary school course in mathematics. The work is so well arranged that teachers who are keen for mental discipline will find it here (if anywhere). Moreover, it will prepare girls to apply their mathematical knowledge in such a way as to meet the needs of trade, commerce, and home life. The value of mathematics in daily life is made so evident by the problems and discussions of important facts that interest in the subject is assured.

The first part includes a review of arithmetic, mensuration, and the interpretation of results. The second part deals with problems in homemaking, distribution of income, food, construction of a house, furnishing a house, and thrift and investment. Part III—Dressmaking and Millinery. Part IV—The Office and Store. Part V.—Arithmetic for Nurses. Part VI—Problems on the Farm. Teachers of vocational courses and teachers of secondary mathematics as well should examine this book.

H. E. C.

*The Home and its Management*, by Mabel Hyde Kittredge, New York City. 385 pages. 13.5x19.5 cm. Cloth. 1917. \$1.50. The Century Company, New York City.

A valuable book which every housekeeper who wishes to practice economy in home management should possess. It contains nineteen chapters in which the essential matters appertaining to successful housekeeping are discussed. Here one finds advice on the best methods of cooking; how to market; the best ways of spending moderate incomes and how to furnish the home practically yet economically. It is well indexed and contains 300 splendid recipes for preparing food. The major paragraphs begin with bold face type. The body of the book is in clear ten point type, and is printed on unaltered paper.

C. H. S.

*The New Barnes Problem Books*, by Abraham Smith, Principal, Public Schools, New York City. Pages 70. 12x19 cm. 10 cents. Paper. 1917. The A. S. Barnes Company, New York.

Problems in arithmetic for the last two years of grammar school are provided in four pamphlets, each covering the work of a half year. Each page is a lesson containing one or more problems that provide for practice in the fundamental operations, constant use of short methods, and review of fractions and fundamental operations. The problems are grouped largely to tell a story; they are well graded and contain much original data.

H. E. C.

*Finite Collineation Groups*, by H. F. Blichfeldt, Professor of Mathematics in Leland Stanford Junior University. Pages xi+193. 13x19 cm. \$1.50, net postage. 1917. The University of Chicago Press.

This volume gives an outline of the different principles of this subject, which at present are to be found mainly in scattered articles in mathematical journals and in a few textbooks on group theory. The author has tried to depend upon a minimum of abstract group theory. The opening chapter develops the fundamental properties of linear transformations and linear groups, requiring no previous knowledge of the technique of group theory. An introduction to the theory of groups of operators and substitution groups is given in the second chapter. The remaining chapters deal with linear groups in two, three, and four variables, advanced theory of linear groups, the theory of group characteristics, and the history and applications of linear groups.

H. E. C.

*A First Course in Higher Algebra*, by Helen A. Merrill, Ph. D., Professor of Mathematics in Wellesley College and Clara E. Smith, Associate Professor of Mathematics in Wellesley College. Pages xiv+247. 13x19 cm. \$1.50. 1917. The Macmillan Company, New York.

Instead of the usual course in college algebra which seems to lead nowhere, this text is a real introduction to some of the methods in analysis which should prove useful and interesting to the student. For the most part the work is based upon limits, with proofs as rigorous as seems advisable for immature students, but the authors hope that there is nothing to be unlearned in later work. Chapter IV, Variables and their Limits, leads to a chapter on the differentiation of algebraic functions and applications in maxima and minima. Further application of differentiation is made in the development of functions in series. The usual topics of the course in college algebra are covered.

H. E. C.

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*The Basis of Durable Peace, by Cosmos, for the New York Times.*  
Pages ix+144. 13.5x20 em. Charles Scribner's Sons, New York  
City.

While the military and political conditions of the world have greatly changed since this book was written, yet the conditions of "Durable Peace" are essentially the same. The discussions here are undoubtedly the most sane and fairly presented of any which have come from the pen of competent writers on this most important question. The intelligent reader must be impressed and convinced with the logic and breadth of the arguments used. This is a book which all folks the world over should read in order to put themselves in touch with the fundamental principles of "Durable Peace."

C. H. S.

*Everyday Physics, a Laboratory Manual, by John C. Packard, High  
School, Brookline, Mass.* Pages vi+36. 20x27 em. Cloth.  
1917. Ginn & Co., Boston.

This is one of the best physics manuals which the writer has had the privilege of reading. The author is a past master in the art of teaching high school physics and out of his many years' experience has produced a book which is second to none ever published. It can be used in connection with any text. The range and class of experiments is such that the pupil may get a good knowledge of the more important physics principles of daily life; at the same time the requirements for entrance to any college may be readily filled. There are 61 specially selected experiments. About 100 well executed drawings and half-tones are included. In the treatment of the experiment a list of apparatus and material to be used is first given. This is followed by an introduction or explanation of the experiment. Next comes the procedure of performing the exercise. Problems directly bearing on the question are also given, together with topics of a kindred nature for further study. The mechanical work is perfection in

bookmaking. The instructor who adopts this manual for his laboratory will not be making a mistake.

C. H. S.

*Elementary Mathematical Analysis*, by J. W. Young, Professor of Mathematics, Dartmouth College, and F. M. Morgan, Assistant Professor of Mathematics, Dartmouth College. Pages xii+548. 13x19 cm. 1917. The Macmillan Company, New York.

College algebra, trigonometry, analytic geometry, and the elements of calculus are here presented as a unified course in freshman mathematics by means of making the concept of a function fundamental throughout. The authors have done a good piece of work, though it is modestly stated in the preface that they do not believe that this text solves the problem of unification. It is to be hoped that it will be widely used so that through trial, suggestions, and modification a real and satisfactory unification of these subjects may be worked out. The problems and discussions have a distinct flavor of originality, and the many questions put among the exercises should stimulate thought and discussion on the part of students.

H. E. C.

*Seventeenth Annual Report of the Director of Education, Philippine Islands*. 31 ages. 18x25.5 cm. Paper. 1917. Bureau of Printing, Manila, P. I.

What marvelous works the educators of the United States have wrought in these islands. It seems almost beyond the power of comprehension that such great results in education could have been accomplished since the Spanish war of twenty years ago. One in reading this report can almost believe that it is a report of some one of the United States of America. There are many splendid half-tones showing the character of the schoolrooms, buildings, and people. There are many tables of statistics that are full of value to the educator.

C. H. S.

*Sixth Biennial Report, State Superintendent of Public Instruction of Oklahoma for 1916*. 252 pages. 15.5x23 cm. Cloth. Oklahoma City.

A report which will surprise many of the people east of the Mississippi River, as from personal knowledge, experience, and acquaintance with hundreds of school men in the eastern part of our country the writer of this paragraph knows perfectly well that many people in the East have an idea that education between the Mississippi River and the Rocky Mountains is at very low ebb. Good education is not confined to the East, as reports like this of superintendents of the work that is being done in the central western states show. The schools of Oklahoma are admirable in their efficiency.

C. H. S.

*The Illinois Survey*, L. D. Coffman, Director. 377 pages. 14x20 cm. Cloth. 1917. Illinois State Teachers' Association, Springfield, Illinois.

School surveys have been the vogue for a few years past. They have had their day. Others will come and go. Some will be worth while, others will be fruitless. This one, undertaken by the Illinois State Teachers' Association, has been productive of very much good. The method of attack was careful study in advance by a committee thoroughly familiar with the work to be done, and they have brought out a report which is second to none in the country. Progressive teachers and those who are willing to be at the forefront of efficiency in the classroom or administrative work should be familiar with this volume.

C. H. S.

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*Abstract of the Census of Manufacturers, Department of Commerce.*  
722 pages. 16x23 cm. Cloth. 1917. 65 cents. Government  
Printing Office, Washington.

A valuable report from all points of view, and one which men engaged in the science of doing efficient business should study, as from it they will gather information which, if incorporated into their business, will assist them in getting larger returns for their investment. The book is filled with tables of statistics which are of the highest value to business men and manufacturers. It surely is to be hoped that firms which are supplying the country with the necessities of life will make better use of the government investigations than they have been doing.

C. H. S.

*Problems in General Science for College Classes, by Morton Masius,*  
*Worcester Polytechnic Institute.* Pages vi+90. 13.5x21 cm.  
1,000 problems. Cloth. 1917. 90 cents. P. Blakiston's Son  
& Company, Philadelphia.

This is a splendid work covering the whole range of physics as it is usually taught in college and university. The author has gathered together a splendid list of problems, and it will be worth while for any college instructor in this subject to secure copies for use in his classes. The problems are of the very highest type.

C. H. S.

*Year Book of the United States Department of Agriculture for 1916.*  
703 pages. 15x23 cm. Cloth. 1917. Government Printing  
Office, Washington.

It is almost useless to attempt in this limited space a comprehensive review of this splendid report. All folk knowing anything about the nature of the work done by our Department of Agriculture will know that this is of the very highest standard of authority, and those interested in agriculture should secure this report not only for the fund of information which it contains, but also to help them to become better acquainted with those phases of life, and, if they are actively engaged in agriculture, to become better farmers.

C. H. S.

*Elementary Principles of Economics*, by Richard T. Ely, University of Wisconsin and George R. Wicker, Dartmouth College. Pages xv+446. 13x19 em. Cloth. 1917. \$1.10. The Macmillan Co., New York.

This is the second edition of this book. The first one appeared several years ago, and it met with approval by all people interested in the subject matter. There are several important changes in the text from the first edition. But these are all for the better. Any production to which the authors of this book have attached their names is sufficiently guaranteed as to value by that signature. Each chapter closes with a summary of the points discussed, along with a set of questions for recitation and a set of questions for study and discussion. At the same time, references are made to various books bearing upon the subject matter discussed in the chapter. The book is divided into four books, and in these are discussed, first "Introductory," second "A Brief Sketch of Economic History," third "Economic Theory," and fourth "Public Finance." The mechanical work on the book is good, the printing exceptionally fine, the paper uncalendered. The book is recommended for every person interested in economics.

C. H. S.

*An Experiment in the Fundamentals of Education*, by Cyrus D. Mead, University of Cincinnati. Pages xiv+54. 12x18 em. Paper-board. 1917. 60 cents. World Book Company, Yonkers, New York.

This is a very unique experiment in the fundamentals of teaching, and was carried out in the several Cincinnati schools by teachers who were selected by the principals of these schools. All those engaged in the experiment are loud in their praise of the idea, and believe that the work was worth while. There are many tables showing the results of the experimental tests. Principals who are considering carrying out a test similar to this in their schools cannot do better than to read this book.

C. H. S.

*High School and College Textbooks; Descriptive Catalogue with price list*. Pages vii+436. 13x19 em. Cloth. 1917. American Book Company, Chicago.

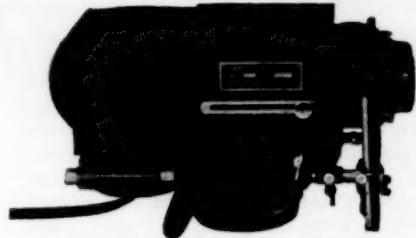
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C. H. S.

*The Electron—Its Isolation and Measurement and a Determination of Some of Its Properties*, by Robert A. Millikan, University of Chicago. Pages xii+268. 13x19 cm. Cloth. 1917. \$1.50. University of Chicago Press.

All teachers of physics in secondary schools, colleges, and universities will thank the author of this book for putting into such a clear and interesting form his recent investigations concerning the nature of the electron. It passes all understanding that it should be possible for an investigator to accomplish the work done by this well known physicist. This is a book which all physicists and laymen interested in the theory of matter and electricity will welcome. The author has done well in separating the mathematical proofs from the main body of the work. One who has not occupied himself in training in the line of physics investigation in the last decade may have some trouble in understanding chapters VII and VIII. Yet if he possesses the desire to know things at first hand he will make himself familiar with the mathematical expressions there presented. The book is written in Dr. Millikan's imitable style, and one knows from the standing of the man that the results of his investigations here given are beyond the shadow of a doubt absolutely authoritative. Undoubtedly the book will have its influence in causing other experimenters to pursue investigations in this same direction. It is simply marvelous that it is possible for man to make such a thorough study of infinitesimals like the electron.

All students of physics should possess this book, and if one wishes to keep abreast of the spirit of the times in this kind of work, he must know the contents of this text. Mechanically, the book is well made, the type clear. There are ten chapters and eight appendices. There is an index of authors quoted, together with a subject index.

C. H. S.

*Negro Education in the United States, prepared under the direction of Thomas J. Jones, Bureau of Education*. 18.5x25 cm. Vol. I, xiv+423 pages. Vol. II, v+724 pages. Paper. Vol. I, \$1.00. Vol. II, \$1.25. Government Printing Office, Washington.

One of the most voluminous reports of this particular phase of educational training that the government has ever prepared. It discusses all forms and kinds of education among the negroes of the South. Space will not permit of an extended review at this time, but we wish to recommend the report most highly, and hope that those who are interested in the education of the negro will secure a copy of the report.

C. H. S.

*Carnegie Foundation for the Advancement of Teaching—11th Annual Report of the President and Treasurer*. 172 pages. 18.5x25.5 cm. Paper. 576 Fifth Avenue, New York City.

This report is valuable to all who are vitally interested in educational work, especially that of the college and university. It gives an outline of the condition of the Fund, this being taken up with the discussion of the opinions and desires of the teachers who are benefited by the Fund, and shows that the Foundation is in harmony with their ideas. The report uses a good deal of space in discussing the recent developments of pensions for teachers and kindred professions. The report is full of information for all of those who may need assistance from this particular force. A copy of the report may be had by addressing the Foundation.

C. H. S.